HEALTH OVER EFFICIENCY: ABANDONING MERCURY USE IN SMALL-SCALE MINING

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INTRODUCTION

The economic crisis of 2008 was devastating for many sectors in the global market. Gold miners were not included in this group. Following the tumultuous environment of the economic fallout, investors sought for a source to invest in that would provide certainty and stability. They found this source in gold. As investments increased, the price of gold followed and between 2008 and 2012 gold had a 101.1% increase in value.[1]

As the price of gold rose, so too did the amount of miners digging for this precious mineral. Globally, at least 70 countries experienced or are

1. Brian Hergt, *Beyond the Numbers*, BUREAU OF LABOR STATISTICS (Feb. 2014), http://www.bls.gov/opub/btn/volume-2/gold-prices-during-and-after-the-great-recession.htm.

continuing to experience a modern day gold rush.[2] A majority of this mining is taking place in less developed and remote regions because that is where miners are able to find virgin ground.[3] One such area can be found in the Amazon Rainforest of South America, where there are more people mining for gold today than there has been at any other time in history.[4]

When Americans think of gold mining usually one of two images come to mind. They may imagine the small-scale miners who, in 1849, traveled to the gold rich streams of the Sierra Nevada Mountains in California to "strike it rich." Alternatively, they may imagine modern day large-scale mining where millions of dollars are invested into the operation and thousands of man-hours are spent utilizing heavy machinery to move mountain in the search for precious metals.

Both large-scale and small-scale mining operations are found in the rainforests of South America. But while the large-scale operations largely comply with the legal and regulatory framework provided by the different governments of the Amazon Countries,[5] the small-scale mining operations fall under the radar of the Amazon Governments[6] because there is a weak state presence in the remote regions where mining is taking place, and the regional governments do not have the necessary resources or manpower to properly monitor and control the small-scale mining industry.[7] The lack of government oversight has allowed for small-scale mining operations to use mercury in the mining process, which is not only hazardous to many diverse species that reside in the Amazon, but it is also dangerous to those involved in the various

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2. Kevin Telmer & Anthony Persaud, *Historical and Modern Government Responses to Artisanal and Small Scale Gold Mining*, 2 ROCKY MTN. MIN. L. FOUND. 18C, 18C-1 (2013).

3. "Virgin ground" is an area that has not previously been mined and were miners are able to find new mineral deposits.

4. Telmer & Persaud, *supra* note 2, at 18C-7.

5. "Amazon Countries" refers to Bolivia, Brazil, Colombia, Peru, and Venezuela.

6. "Amazon Governments" refers to the governments of each of the Amazon Countries: Bolivia, Brazil, Columbia, Peru, and Venezuela.

7. Miguel Angel Soto, *Small-scale and Illegal Mining in Peru*, 2 ROCKY MTN. MIN. L. FOUND. 18B, 18B-4 (2013).

processes used to extract, refine, and process gold, as well as those living near or downstream from the mining activity.

Mercury is used in the small-scale mining industry because the miners are able to use it to efficiently capture gold without having to invest in other, more costly, gold recovery equipment or processes. While these processes may be cost effective, mercury emissions from small-scale mining operations present a real and serious threat to the environment and to the growing populations involved in the mining industry.[8] Although it is relatively safe to handle mercury in its elemental form, the processes being used by small-scale miners to recover and process gold converts elemental mercury into organic methylmercury, or mercury fumes when it is heated. Both can be extremely hazardous to humans and many other creatures in the Amazon. The small-scale mining industry has exacerbated the dangers that mercury poses on the populations in the Amazon Counties, and steps need to be taken to minimize these hazards.

I. MERCURY AND ITS USE IN SMALL-SCALE GOLD MINING IN SOUTH AMERICA

Although evidence suggests that pre-Inca civilizations were engaging in small-scale gold mining in South America extending back to 2000 BC,[9] amalgamation processes, whereby mercury is used to separate gold from other materials, were not used in South American mining until the 16th century when Spanish miners[10] adopted the process for use in silver mining.[11] It has been estimated that the Spanish used 196,000 tons of

8. M. Babut et al., *Improving the Environmental Management of Small-Scale Mining in Ghana: A Case Study of Dumasi*, 11 J. OF CLEANER PROD. 215, 220 (2003).

9. Jelmer W. Eerkens et al., *Pre-Inca Mining in the Southern Nasca Region, Peru*, 83 ANTIQUITY 738, 739 (2009).

10. While Christopher Columbus' first voyage across the Atlantic Ocean was in the name of discovery, the second voyage to the "Far East" included 1,500 miners and technicians to seek out and mine precious mineral deposits. *See* David K. Fargin, *An Overview of Natural Resources Development in Latin America*, 4 ROCKY MTN. MIN. L. SPECIAL INST. 36A (1994).

11. Marcello M. Veiga et al., *Origin and Consumption of Mercury in Small-Scale Gold Mining*, 14 J. OF CLEANER PROD. 436, 438 (2006).

mercury between 1554 and 1880 in the processing and extraction of precious metals, not including gold.[12]

While mercury was used in gold mining in other regions of the world, it was not used in South American gold mining until the 1980s, during the *garimpeiro* gold rushes[13] in Brazil.[14] During the Brazilian gold rushes, mercury was placed directly on sluice boxes so that the miners could quickly amalgamate large quantities of ore.[15] Although this process is quick, it is common to lose three times the amount of mercury as gold collected.[16]

This process originated in Brazil, but it quickly spread throughout small-scale gold mining operations in the surrounding Amazon Countries.[17] Following the Brazilian gold rushes, between 1980 and 1990, Chile and Columbia both experienced a modest increase in gold production, which was preceded by increased small-scale mining activities spreading to Peru from 1992 to 2001.[18] While mining activity has fluctuated throughout the Amazon Countries, overall, small-scale mining steadily increased during modern times[19] and has increased, in

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12. *Id.*

13. The gold rushes in *garimpeiro* were a result of increased gold prices that were a result of President Richard Nixon eliminating the gold standard in 1971. As prices increased, gold mining became a feasible profession and during the *garimpeiro* gold rushes in Brazil nearly 100,000 sugar cane workers quit their jobs and began working square meter plots at Serra Palada (the naked Hill). *See* Telmer & Persaud, *supra* note 2, at 18C-6.

14. Gavin Hilson, *Abatement of Mercury Pollution in the Small-Scale Gold Mining Industry: Restructuring the Policy and Research Agenda*, 362 SCI. OF THE TOTAL ENV'T. 1, 3 (2006).

15. *Id.*

16. *Id.*

17. *Id.*

18. Abraham Kumah, *Sustainability and Gold Mining in the Developing World*, 14 J. OF CLEANER PROD. 315, 318 (2006).

19. *See* Olaf Malm, *Gold Mining as a Source of Mercury Exposure in the Brazilian Amazon*, 77 ACAD. PRESS 73, 73 (1998). The small-scale mining industry is not limited to the actual miners digging for gold. The industry encompasses many sectors of the market and included retail merchants, health providers, gold shops, gold refiners, financiers, claim holders, manufacturers, and many other service providers. Telmer & Persaud, *supra* note 2, at 18C-5.

some regions, by 400% since 1999[20] because the recent increase in gold prices has allowed many unskilled laborers, mainly living in remote regions, to participate in mining to supplement or replace their seasonal agricultural based incomes.[21] For example, 400,000 unskilled workers have supplemented or abandoned their agricultural work to work in small-scale mines near the Madre de Dios River.[22]

As small-scale mining activity has increased, so too has the amount of mercury that is being released into the rivers and atmosphere of the Amazon.[23] Due to increases in mining activity, small-scale gold mining is currently the largest source of "anthropogenic mercury" with 1,763 tons of mercury being released into the atmosphere, water systems, and soils in 2012,[24] with eleven to thirty-three tons of mercury being released into each of the environments of Bolivia, Brazil, Colombia, Peru, and Venezuela annually.[25]

A. The Use of Mercury and The Hazards of Small-scale Mining

There are many reasons why mercury amalgamation is used by small-scale miners. It is inexpensive, easy to use, commonly available, and the recovery processes that utilize mercury are relatively effective and can be used by a solo miner, even in the remote jungle regions because little technology or infrastructure is required.[26] A widely accepted and unfortunate explanation is that miners are merely "disregard[ing] environmental and health-related issues"[27] or are not aware of the health

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20. Rhett A. Butler, *Gold Mining in the Amazon Rainforest Surges 400%*, MONGABAY.COM (Oct. 28, 2013), http://news.mongabay.com/2013/1028-amazon-gold-mining.html.

21. Veiga et al., *supra* note 11, at 436.

22. Paulo De Sa, *Beyond Illegality: Concepts and Approaches Towards Improved Governance of Informal Mining*, 2 ROCKY MTN. MIN. L. FOUND. 18A, 18A-4 (2013). These miners are producing nearly one-fifth of Peru's annual 175 metric tons of gold. *Id.*

23. Malm, *supra* note 19, at 73.

24. Telmer & Persaud, *supra* note 2, at 18C-8.

25. Veiga et al., *supra* note 11, at 438.

26. *See* Telmer & Persaud, *supra* note 2, at 18C-8; *see also* Veiga et al., *supra* note 11, at 438.

27. Hilson, *supra* note 14, at 2.

risks associated with using mercury amalgamation.[28] This problem is intensified by the lack of education amongst the miners. The uneducated groups have been skeptical about abandoning the efficient and cost effective processes because they have not been convinced that using mercury is harmful to them. This may be because they are unable to see any type of correlation between using mercury and any adverse symptoms because contamination is not instantaneous and often takes years of exposure to mercury, through consumption or inhalation, to accumulate in the bloodstream or kidneys before crossing the blood-brain barrier and inducing a wide-range of neuropsychological disorders.[29]

The Amazon Governments have recognized that there are health risks associated with using mercury and have made it illegal to use, or have regulated the use of, mercury in gold mining. This has not stopped miners from being able to obtain mercury because they are able to purchase large quantities of mercury for "dental use," which continues to be a legal way for anyone to purchase mercury in most countries and allows small-scale miners to easily obtain mercury for use in mining.[30]

Although it is illegal to use mercury, the advantages of using it have led the small-scale miners to continue to use mercury in mining. Small-scale miners use mercury for its unique characteristic. Due to its surface tension being greater than that of water but less than that of gold, it adsorbs onto the surface of gold particles, which causes the gold to sink into the dense mercury, while lighter gangue material is separated from the amalgam.[31] Mercury is introduced into the environment during different stages in the mining process. The first introduction of mercury happens during the final recovery process where the gold is separated and extracted from other minerals and sand through amalgamation.[32] The second is during the gold refinement processes where mercury is released into the atmosphere as a vapor.

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28. Veiga et al., *supra* note 11, at 438.
29. Hilson, *supra* note 14, at 2.
30. Veiga et al., *supra* note 11, at 441.
31. *Id.* at 438.
32. Malm, *supra* note 19, at 73.

Two different amalgamation methods are used in small-scale mining operations: whole ore amalgamation and amalgamation of only gravity concentrates.[33] In whole ore amalgamation mercury is spread onto riffled concentration sluices in order to trap the gold, which is formed into a solid amalgam.[34] During this process 100% of the mined ore comes in contact with mercury as it passes through the sluice.[35] The result is that mercury-contaminated tailings are introduced into the environment through the mismanagement of the waste products that occur as a result of the mining and processing activities because the miners are not using, are not able to afford to use, or are not aware of pollution control measures, such as tailings impoundments, that would limit the direct and indirect introduction of mercury into the rivers.[36]

In the amalgamation of only gravity concentrates, on the other hand, "mercury is mixed with concentrates in blenders or barrels; [and the] separation of amalgam from the heavy minerals is accomplished by panning in water boxes, pools or at creek margins."[37] This process decreases the amount of material that comes in contact with the mercury, which also decreases the amount of mercury that is lost because the gold bearing materials have been separated from the majority of the gangue material, and although less mercury is used, it still finds its way into river systems because there is nothing being done to stop the mercury from leaching into the environment.[38]

During amalgamation, mercury is introduced into the environment from the discharge of tailings, which are inadequately managed and often deposited near rivers.[39] These tailings release "large quantities of noxious atmospheric mercury . . . as well as significant amounts of metallic mercury" into the surrounding environment.[40] In turn, these releases find their way into rivers where they "bioaccumulate in aquatic ecosystems

33. Veiga et al., *supra* note 11, at 438.
34. *Id.*
35. Telmer & Persaud, *supra* note 2, at 18C-8.
36. N. Håkan Tarras-Wahlberg et al., *Environmental Impact of Small-Scale and Artisanal Gold Mining in Southern Ecuador*, 29(8) J. HUM. ENV'T 484, 484, 490 (2000).
37. Veiga et al., *supra* note 11, at 438.
38. *Id.* at 439.
39. Tarras-Wahlberg et al., *supra* note 36, at 485.
40. Hilson, *supra* note 14, at 2.

and are eventually transformed into toxic methylmercury . . . by micro-organisms."[41]

Once in the river systems, bacteria in soils and sediments convert the mercury used during the mining process into methylmercury through a process called bioaccumulation,[42] which is especially a problem in the rivers of the Amazon Rainforest because mercury methylation is favored by the abundance "of organic matter and . . . intense bacterial activity" that is found in rainforests.[43] The methylmercury then makes its way through the food chain causing it to accumulate in higher concentration further up the food chain where small fish are exposed to methylmercury and are then consumed by larger fish.[44] These larger predatory fish are one of the main sources of food Amazon River basin,[45] and a majority of the human population in the basin can be exposed to mercury through the food chain. This occurs even though only a small percentage of the population is actually involved in mining and the mining process.

The second type of exposure occurs during the burning and re-burning of amalgams (bullion) during the smelting process.[46] "When the . . . amalgam is heated," the mercury burns off and is turned into a vapor, "leaving [behind] impure gold." [47] The miners are exposed to extremely high concentrations of mercury fumes when burning amalgam at the mines themselves. Although the miners are directly exposed to high concentrations of mercury fumes, this process takes place in the open air and occurs infrequently – anywhere from once a week to a couple times

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41. *Id.*

42. EPA, *How People are Exposed to Mercury*, U.S. ENV'T PROT. AGENCY (Dec. 17, 2013), http://epa.gov/mercury/exposure.htm#epa.

43. Wolfgang C. Pfeiffer et al., *Mercury Concentrations in Inland Waters of Gold-Mining Areas in Rondonia, Brazil*, 87/88 SCI. OF THE TOTAL ENV'T 233, 234 (1989).

44. EPA, *supra* note 42.

45. *See* LISA WALDICK, MINING, CONTAMINATION, AND HEALTH IN ECUADOR 3 (2003) (Fish is the main source of food for the indigenous people because they can catch the fish at no cost to them. The people are largely unaware of the health risks associated with the contaminants and pollution added to the rivers in the mining process and most believe that "the fast-running water of the river means that they are protected from pollution.").

46. Malm, *supra* note 19, at 75.

47. Veiga et al., *supra* note 11, at 438.

a month.[48] The gold dealers and refiners, on the other hand, are exposed to lower concentrations of mercury fumes during the re-burning process, but the process usually takes place indoors and occurs on a daily basis.[49] This means that the mercury fumes are not as easily dissipated and the dealers are exposed, overall, to greater amounts of mercury. When mercury fumes are inhaled, the mercury is absorbed through the lungs and travels through the blood stream where it eventually accumulates in the lungs.[50]

Exposure to mercury varies from region to region. Mercury levels above acceptable limits have been found in 76.5% of people in both the rural and urban populations living near to or downstream from small-scale mining operations.[51] While contamination rates vary, higher exposure rates and levels are typically found in areas that are close to or downstream from mining activities.[52] Several factors lead to this result, but the highest mercury levels usually correspond to a heightened exposure to mercury-contaminated fish.[53]

Adults who are exposed to mercury have been known to have neurological problems, which can result in tremors, due to loss of cognitive and motor functions. Damage can also occur "to the thyroid, lungs, kidneys, immune system, eyes and skin."[54] Mercury exposure can be even more dangerous to children because it can cause "profound neurological and developmental problems, mental retardation, seizures,

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48. Malm, *supra* note 19, at 75.

49. *Id.*

50. *Id.*

51. Simeon Tegel, *Gold Rush Sparked by Global Financial Crisis Devastates Amazon*, NBC NEWS (Dec. 23, 2014), http://worldnews.nbcnews.com/_news/2013/10/29/21232661-gold-rush-sparked-by-global-financial-crisis-devastates-amazon.

52. *See, e.g.*, Pfeiffer, *supra* note 43, at 236.

53. Carlos J. S. Passos & Donna Mergler, *Human Mercury Exposure and Adverse Health Effects in the Amazon: A Review*, 24 CAD. SAUDE PUBLICA 503 (2008), http://www.scielo.br/pdf/csp/v24s4/04.pdf.

54. NRDC CASE STUDY: NRDC HALTS MERCURY CONTAMINATION AROUND THE GLOBE 1 (2013), *available at* http://www.garfieldfoundation.org/resources/docs/FINAL_mercury%20treaty%20case_march%2013.pdf.

loss of vision, and hearing loss."[55] Also, pregnant women and women who breastfeed may endanger the health of their child by exposing the developing fetus or child to methylmercury, even if the women does not show any symptoms of mercury poisoning.[56] This is because the immune systems of a fetus or a young child are not as developed as an adult and smaller amounts of methylmercury are needed to negatively affect the development of a growing brain.[57] Exposure to methylmercury is hazardous to anyone who comes into contact with enough of it, and it can be especially disruptive during early phases of human development.

II. INITIATIVES TO LESSON THE USE OF MERCURY

In South America, the negative effects of mercury on the environment and human health are well documented. Nevertheless, small-scale miners continue to carelessly use mercury in the gold refining process.[58] This fact emphasizes the "urgent need for research on how to minimize mercury consumption" within small-scale mining communities who may be unaware of the hazards of using mercury.[59] It is deemed unlikely that existing government programs, environmental regulations, or private initiatives will be sufficient to limit the amount of mercury that is being introduced into the environment.[60] Government responses have been inadequate and sporadic, and the miners themselves lack the training and finances to initiate widespread changes. Furthermore, because the mercury poisoning is being suffered downstream from the mining districts, the miners are unaware of the problems they are causing.

Although these issues have created a vast problem that extends throughout the entire Amazon region, all is not lost. It is not too late to change the behavior of the small-scale miners and there are three

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55. *Id.*
56. EPA, *supra* note 42.
57. *Id.*
58. Jesper Bosse Jønsson et al., *A Matter of Approach: The Retort's Potential to Reduce Mercury Consumption in Small-Scale Gold Mining Settlements in Tanzania*, 17 J. OF CLEANER PRODUCTION 77, 78 (2009).
59. *Id.*
60. Tarras-Wahlberg et al., *supra* note 36, at 3.

different avenues where changes may be made.[61] First, small-scale miners need to be better educated on health hazards associated with using mercury and how to minimize environmental damage. It is often true that the miners are not aware that mercury can be hazardous to their health and the health of those living near or downstream from the mining operations.[62] Second, the Amazon Governments need to enact legislation that will encourage the miners to limit or abandon processes that release mercury into the environment.[63] Third, the Amazon Countries should ratify and enforce the Minamata Convention on Mercury, which aims to limit the availability and use of mercury throughout the international community.[64]

A. Education of the Small-scale Miners

One of the easiest ways that mercury can be removed from small-scale mining is through educating the miners and by providing them with training on other processes that can replace the methods that are presently being used. Through training, potential misconceptions can be easily corrected by providing the small-scale gold miners with information that informs the miners about the possible hazards of using mercury.[65] Also, training can provide small-scale miners with demonstrations on how to use other mercury-free gold extraction methods[66] that will limit the amount of mercury being released into the environment.

One possible short-term solution might be introducing retorts into the small-scale mining community. Gold extraction using iron retorts is commonly referred to as effective, environmentally sound, and appropriate for small-scale miners. [67] "Retorts are simple, inexpensive

61. *Id.*

62. Zoë Amerigian & Lindsey Pace, *Gold Digging in Colombia: Mining Throughout Latin America*, COUNCIL ON HEMISPHERIC AFFAIRS (Jan. 23, 2014), http://www.coha.org/gold-digging-in-colombia-mining-throughout-latin-america/.

63. Tarras-Wahlberg et al., *supra* note 36, at 3.

64. Telmer & Persaud, *supra* note 2, at 18C-8.

65. Amerigian & Pace, *supra* note 62.

66. Jønsson et al., *supra* note 58, at 78.

67. *See id.*

and robust devices that can be used to collect mercury fumes, which can recycle 95% of the mercury used during gold extraction" by collecting the mercury fumes, instead of allowing them to enter into the atmosphere.[68] A retort is constructed by connecting a closed crucible to a condenser so that, as the amalgam is heated, the mercury collects in the condenser.[69] This allows the small-scale miners[70] to collect the mercury while it is in a stable state, instead of allowing the mercury to enter into the atmosphere as fumes during the refining process and also saves the small-scale miners money by recycling mercury to be used again instead of being lost to the environment.[71]

Using retorts seems like a simple way to limit the amount of mercury released into the environment, but there are also challenges presented when attempting to get small-scale miners to use retorts because they may be inappropriate given the technological and societal context in which small-scale mining takes place.[72] Groups who have tried to introduce retorts to small-scale miners have run into a variety of problems that one may not think about when attempting to introduce the equipment into a mining region. For example, the United Nations Industrial Development Organization (UNIDO) has had difficulties introducing retorts into certain regions because of what they call the "black box effect."[73] This problem arises in regions where the miners, because of limited access to education and training, are convinced that gold is lost when retorts are used because they are unable to see the actual refinement process.[74] This has created a situation where miners are unwilling to use retorts because it would not be worth it to the miners if any gold were lost during the refinement process.

Local knowledge and solicited feedback from operators are the keys to devising appropriate solutions to the mercury problem in the small-

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68. *Id.*
69. Babut et al., *supra* note 8, at 219.
70. Retorts may also be used by gold refiners, who are at a greater risk of breathing in the toxic fumes.
71. Jønsson et al., *supra* note 58, at 81.
72. *Id.* at 78.
73. Babut et al., *supra* note 8, at 219.
74. *Id.*

scale gold mining sector.[75] This has been demonstrated on many occasions with retorts, which have largely been designed[76] "outside of the South American Countries and promote[d] . . . without assessing [the] feasibility," of the devices. Accordingly, small-scale miners have rejected the expensive and complicated designs, "resulting in low levels of adoption." [77] Alternatively, "positive results have been achieved in cases where equipment has been designed using local materials with which local groups are more familiar."[78] For example, in response to the "black box" problem, UNIDO designed and introduced a transparent retort where the miners are able to actually view the heating and separation of mercury from the gold.[79] While this solved one problem, it also created others where the product is now too expensive for the miners to be able to afford—only small quantities of amalgam can be refined at a time, and the product is easily broken, which is not an ideal characteristic for equipment that will be used at a gold mine in the middle of the Amazon Rainforest.[80]

While retorts are effective at eliminating the release of mercury into the atmosphere, they do nothing to limit the loss of mercury during the gold recovery process and still create a situation where miners are being exposed to and using mercury.[81]Also, although many NGOs and governments have pledged millions in funding to study and limit the use of mercury in small-scale mining over the last fifteen to twenty years, these programs have failed to make any widespread impact and the use of mercury has intensified and increased throughout the majority of the Amazon mining areas.[82] Gavin Hilson, a leading authority on the environmental and social impacts of the small-scale mining sector, provides an explanation for this discouraging result. He explains that the majority of time and efforts have been spent conducting repetitive studies

75. Hilson, *supra* note 14, at 10.
76. *Id.*
77. *Id.*
78. *Id.*
79. Babut et al., *supra* note 8, at 219.
80. *Id.*
81. *See id.*
82. Hilson, *supra* note 14, at 4.

that research the effects of mercury contamination in mining communities and wildlife, while little has been done to actually change the behavior of the miners.[83] In some cases the research, while being published in scientific journals, has not been shared with the actual communities involved in the studies.[84] If the research is not being shared with the very populations that are at risk from using the hazardous material being studied, then the funding is being used in an ineffective way.

Hilson argues that a more effective means of research is one that includes anthropological components, where the "work [is] geared toward ascertaining levels of awareness of mercury-related issues, improving understanding of population dynamics, and desensitizing communities to mercury-abatement technologies."[85] Using this method, research can be conducted in a way that will identify situation specific solutions to eliminate or limit mercury use in small-scale mining, and training and educational programs can then be designed to change the behavior of specific groups of miners.

An example of the effectiveness of this method can be shown through a study done in Brazil. Brazilian small-scale miners seem unconvinced that coming in contact with mercury, in specific circumstances, can be lethal, and they do not respond positively to educational materials and presentations that focus on health and the environment.[86] On the other hand, the Brazilian small-scale miners are extremely concerned about the hazards of mercury when the materials presented to the miners focus on risks of impotency associated with coming into contact with mercury.[87] In order to design an effective educational seminar for these miners, the presenters would need to understand and take this information into account when designing any type of educational seminar, because if the presenter uses the "generic" presentation, which focuses on lethality, their efforts will be wasted.

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83. *Id.*
84. *Id.* at 5.
85. *Id.*
86. *Id.* at 6.
87. *Id.*

To utilize this information most effectively, the programs also need to be reoccurring on an ongoing basis and throughout all areas of the Amazon countries. Thus far, educational training efforts have occurred in short-term barrages that tend to focus on larger urban areas.[88] These types of educational training efforts do not tend to work in the small-scale mining industry because the miners tend to live in remote communities, and there is a continuous influx of miners because small-scale mining is such a rapidly growing industry.[89]

The way that the training and educational material is presented to the miners is also important to successfully introducing measures to control or limit mercury. Previous attempts to educate miners about the hazards of using mercury have failed because the small-scale miners have not been convinced of mercury's toxicity.[90] Presentations and demonstrations, although attended by the small-scale mining populations, have failed to change current practices. The problem with these past programs may have been in the way that they are introduced to the miners.

Recent studies have shown that the success of "any attempt to introduce small-scale miners to new technologies lies in the appropriateness of the technology and the way in which it is introduced."[91] Small-scale miners characteristically are "poor, hardworking, illiterate, with little or no formal education, under health stresses, malnourished and often somewhat transient."[92] As a result, they are often cautious about making any changes in their mining operations, especially when they are unsure that they will benefit from the changes. However, "they are likely to embrace new technologies and extraction methods that offer tangible livelihood improvements . . . if the technology is affordable and presents the possibility of financial gains," so long as the programs are designed to emphasize the monetary value of adopting retorts, or some other method.[93]

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88. *Id.*
89. *Id.*
90. *Id.* at 2.
91. Jønsson et al., *supra* note 58, at 81.
92. *Id.*
93. *Id.*

In order to ensure the long-term sustainability of educational and technological initiatives that will limit the use of mercury in small-scale mining, local ownership and involvement is essential.[94] Small-scale miners will be more willing to attend the educational programs and adopt the technological improvements if dominant miners in the different regions sponsor, recommend, and are on board with the different programs that are introduced.[95]

1. Removal of Mercury Emissions in Small-scale Refining

In 2008, the Environmental Protection Agency of the United States (EPA) published a report on a program that was designed to provide information and training to refiners in the small-scale mining industry, concerning the potential dangers of inhaling mercury fumes.[96] This program was introduced in the Tapajos Region of Brazil and in the Madre de Dios region in Peru, where the EPA was able to provide, through a contractor Argonne National Laboratory (ANL), demonstrations and training on ways to reduce mercury emissions during the refining process.[97] ANL introduced a low-cost emissions control system that was tailored to the specific needs for the miners in these specific regions and was "designed to limit release of mercury from secondary gold refining [that] is carried out in enclosed gold shops, which are prevalent throughout the Amazon."[98]

The project was successful in completing its intended mission of providing demonstrations of ways for local gold refiners to reduce mercury emissions associated with gold shops, and using local materials and contractors to construct mercury capturing systems that would be inexpensive and easy to construct, but would also be effective.[99] Due to

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94. Hilson, *supra* note 14, at 12.
95. Jønsson et al., *supra* note 58, at 82.
96. Babut et al., *supra* note 8, at 219.
97. *Mining Overview*, UNITED NATIONS (Jan. 23, 2014), http://www.un.org/esa/dsd/dsd_aofw_ni/ni_pdfs/NationalReports/usa/mining.pdf.
98. *Id.*
99. L.J. HABEGGER ET AL., TECHNOLOGY DEMONSTRATION FOR REDUCING MERCURY EMISSIONS FROM SMALL-SCALE GOLD REFINING FACILITIES, *available at* http://www.ipd.anl.gov/anlpubs/2008/06/61757.pdf.

the successful implementation of the gold shop mercury capture system, the EPA has moved the program into its "replication phase," where "the Agency is providing training and outreach for its further dissemination and sustainability."[100] The local gold refiners are following the design of the programs and are working with the metal workers in the mining regions to construct the mercury recovery systems.[101] Also, the government of Peru, through the Ministry of Energy and Mines, is taking the lead on replication of the technology across Peru, and is providing assistance to the gold refiners by offering workshops demonstrating the proper use of the technology and is also distributing information, to those in the mining industry, about the benefits of using the technology.[102] This information is available in Portuguese, Spanish, and French, which speaks to the diversity of the people in the mining industry and highlights the broad extent of people who are affected by the continued use of mercury in small-scale mining.[103]

B. Illegality in Small-scale Mining: Recommended Government Action

The lack of enforced regulations is one of the most hazardous problems in small-scale mining.[104] Despite efforts by international agencies such as the International Labor Organization, the United Nations Environmental Program, and the World Bank to develop mine site standards, few countries have sufficient mechanisms in place to enforce and monitor adherence.[105] Therefore, Government response to the small-scale mining industry have been unsuccessful in addressing the problems associated with the gold recovery process and have been characterized by "marginalization, criminalization, and the attempted application of laws dominantly borrowed from the modern industrialized

100. *Mining Overview*, *supra* note 97.
101. *Id.*
102. *Id.*
103. *Id.*
104. De Sa, *supra* note 22, at 18A-9.
105. *Id.*

mining sector," which were not designed to address the issues associated with small-scale mining.[106]

In the 1990s South American countries started to initiate mining regulations that were implemented to encourage practices that prevent environmental damage.[107] Recognizing the importance of environmental issues, Brazil adopted measures to promote mining activity while also protecting the environment.[108] For example, the Brazilian federal government acknowledged the conclusion of a work drawn up by the Ministry of the Environment, Hydric Resources and Legal Amazonia, which "stresses government responsibility in the establishment of strategies, plans and policies for compatibility between the environment and development."[109] This work "identified the basic principles and actions necessary for mining activity to develop within the precepts of environmental conservation and sustainability, from the exploration phase, through the subsequent stage, and up to shutting down the undertaking."[110]

Without a doubt, Brazilian Environmental Law had taken great steps to create environmental protective measures, but the agencies in Brazil and the rest of the South American countries have not been able to properly regulate and manage the widespread mining operations that are often located in remote regions in the Amazon rainforest.[111] In more recent cases, Amazon Governments have actually allowed the use of mercury because it is the "only affordable option for [small-scale miners]."[112] The Brazilian government also requires that the miners use

106. Telmer & Persaud, *supra* note 2, at 18C-4.

107. Carlos Americo et al., *An Overview of Gold Prospecting in Brazil—And—UBI Lex Non Distinguit: Mining Companies and the Relations with Prospecting—The Case of Gold Mining in Brazil*, 14 ROCKY MTN. MIN. L. INST. 46A (1997).

108. *Id.*

109. *Id.*

110. *Id.*

111. *Id.*

112. Catarina Chagas, *Use of Mercury in Gold Mining Stirs Controversy in Brazil*, SCI. DEV. NET (Jan. 8, 2012), http://www.scidev.net/global/health/news/use-of-mercury-in-gold-mining-stirs-controversy-in-brazil.html.

retorts but lack of enforcement measures prevent the miners from ensuring that the miners follow these requirements.[113]

The Amazon Governments should make it a priority to crack down on these illegal mining operations, which "do not respect any regulations and are not held accountable for pollution or on-site accidents," to prevent further environmental and health hazards associated with the use of mercury.[114] It is clear from the widespread and abundant clearing of the forest, opening of trenches, contamination of waters by the indiscriminate use of mercury and other environmental damages, that the previous efforts made by Brazil and other Amazon Countries have reversed course and mining operations are once again commonly occurring in the Amazon Rainforest.[115]

These failures are often attributable to the limited government presence that is found in the remote mining areas of the Amazon Countries.[116] As it is, the current legal and regulatory framework does not sufficiently address the environmental and health risks associated with small-scale mining, and the lack of regulation exacerbates the vulnerability of small-scale miners to the potential hazards associated with illegal mining. So far, the government's response has been focused on pushing small-scale miners into "absolute compliance" with licensing requirements, rather than introducing solutions that are tailored to specifically address the environmental and health hazards generated by mining activity. While this technique has seen limited success, recently, the efforts have been stifled by "a variety of technical, security, and institutional reasons."[117]

Another reason that these environmental regulations have not led to changes in the mining industry is that miners are simply not able to comply with the regulations.[118] In most situations the miners do not have the capital or technology required to make changes to their mining operations that will allow them to upgrade their equipment or purchase

113. *Id.*
114. Amerigian & Pace, *supra* note 62.
115. Americo et al., *supra* note 107.
116. De Sa, *supra* note 22, at 18A-13.
117. *Id.* at 18A-2.
118. Telmer & Persaud, *supra* note 2, at 18C-4.

new equipment capable of capturing and recycling mercury.[119] Legal reform may be used to encourage miners to make these changes that they could not otherwise make on their own by providing access to capital or through incentives that promote upgrading equipment.[120]

1. Formalization of the Small-scale Mining Industry

The Amazon Governments have run into one problem in particular that is preventing them from enacting the necessary changes. The majority of small-scale miners operate outside of legal frameworks.[121] Because they do not operate under existing laws, the miners are not able to receive government assistance or credit from a legitimate source. This also means that miners are in a position where they are unwilling to invest in an operation when they can easily be removed from their lands for many different reasons, including large-scale industrialized miners obtaining permits to operate on the land that was being working by the small scale miners, because the small-scale miners do not have any formal rights over their mining activity.[122] Without formal legal rights, the small-scale miners do not have any incentives to comply with environmental legislation because they do not receive any of the benefits that can be offered to encourage investment and use of mercury-free mining.[123]

In order for formalization to be able to work with small-scale mining operations, the Amazon Governments are going to have to adapt current

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119. *Id.*

120. *Id.*

121. De Sa, *supra* note 22, at 18A-4. According to an analysis conducted by the General Comptroller in 2010-2011, there were as many illegal mines in some regions of the Amazon Counties as there are legal ones. For Example, in Columbia it was estimated that there was 9,420 illegal small-scale mines, compared to 9,230 legal small-scale mines. *Id.* at 18A-13. The miners operating outside of legal frameworks are divided into two different categories: illegal miners and informal miners. *Id.* While some counties treat the two categories differently under their legal systems, for the purpose of this paper both illegal and informal miners will be grouped into a single category where the miners are using the same type of equipment and procedures in the gold recovery and refining process. *Id.*

122. *Id.* at 18A-12.

123. *Id.* at 18A-13.

legislation to conform to the nature of the small-scale mining market. For example, current legislation requires that formal miners obtain a mining title for the mineral rights but small-scale miners often live in communities that have a different understanding of land ownership rights where the miners do not claim ownership over land.[124]

Some governments have already recognized the need to adapt to the different circumstances encountered in this modern gold rush and have begun to make the changes necessary to improve the current legal imbalances that weigh in favor of large-scale industrialized mining. The Government of Columbia, recognizing the problems created by requiring small-scale miners to obtain a mining title, has set aside 2.9 million hectares for minable land in areas known as Strategic Mineral Reserve Areas.[125] In these areas, the miners are not required to obtain a mining title and the Columbian Government has specifically set aside these lands to "improve technical, environmental and social standards of mining activities in these areas, while also providing further and more accurate revenues for the government in the form of royalties and taxes."[126]

The formalization of small-scale miners should be a top priority for the Amazon Governments but it needs to happen in ways that recognize and conform to the current market for small-scale mining. This will not only provide miners with training, capital, and resources, but it will also ensure that the miners are able to operate and provide for their families outside of the illegal market, where miners can be taken advantage of by having to purchase mercury at increased black market prices, and there will be no risk of the miners being pushed off of their land by other formalized mining operations. If the Amazon Governments do not take these necessary steps to enact changes to the current legal situation, the small-scale miners will be left without any incentives that will encourage the rejection of processes that utilize mercury in the recovery and refinement of gold.

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124. *Id.* at 18A-12.
125. *Id.*
126. *Id.*

C. Minamata Convention on Mercury

The use of mercury in small-scale mining is not limited to South America and in February 2009, 92 countries reached an agreement and signed the Minamata Convention on Mercury (Treaty). [127] The Treaty is named after the city of Minamata, Japan, which is the location of the first, well documented and widespread case of mercury related poisonings.[128] In Minamata, local villagers began to notice that large numbers of dead fish and birds were appearing in the bay near the town.[129] Also, other strange occurrences were taking place, such as birds losing their ability to fly and cats dying due to uncontrolled convulsions.[130] Soon after these strange events started taking place, a large number of babies, being the most vulnerable to methylmercury poisoning, being born were showing similar unexplained symptoms such as ataxia, numbness in the hands and feet, general muscle weakness, narrowing of the field of vision, and damage to hearing and speech. In extreme cases, insanity, paralysis, coma, and death follow within weeks of the onset of symptoms.

While the symptoms are severe, they can be easily avoided if mercury is prevented from being deposited into the environment. The Treaty aims to ensure that this happens and has the purpose of protecting others from suffering the same fate as those in Minamata through reducing the release of methylmercury into the environment by enacting procedures intended to reduce global mercury use, supply, and trade.[131]

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127. *Mercury Pollution: An End in Sight?*, NATIONAL RESOURCES DEFENSE COUNCIL (Dec. 26, 2014) http://www.nrdc.org/international/ftoxic.asp.

128. Keiko Tanaka, *92 Countries Sign Minamata Convention to Prevent Mercury Poisoning*, GLOBAL VOICES, (Oct. 23, 2013, 10:57 PM), https://globalvoicesonline.org/2013/10/23/minamata-convention-on-mercury-adopted/.

129. *Id.*

130. *Id.*

131. NATIONAL RESOURCES DEFENSE COUNCIL, *supra* note 127.

1. Limiting the Use of Mercury in Small-scale Gold Mining: Education, Credit, & Technological Assistance

The drafters of the Treaty, recognizing the problems associated with illegal and informal industry, have recommended measures that are meant to lead to global formalization of small-scale mining operations by ensuring that the miners have access to training, credit, and cleaner technologies.[132] Without access to training, credit, and technologies the small-scale miners would be left in a position where they would be unable to alter their mining operations which could lead them to purchase mercury in illegal markets where they are "vulnerable to criminal networks that control parts of the mercury and gold trade."[133] The Treaty "stress[es] the importance of financial, technical, technological, and capacity-building support, particularly for developing countries, and countries with economies in transition, in order to strengthen national capabilities for the management of mercury and to promote the effective implementation of the Convention."[134]

Article 7 of the Treaty specifically applies to small-scale gold mining and processing in which mercury amalgamation is used to extract gold from ore and requires that each party to the Treaty, where small-scale mining occurs, take steps to reduce, and where feasible, eliminate the use of mercury and mercury compounds in, and the emissions and releases to the environment of mercury from, such mining and processing.[135]

> Parties[136] may cooperate with each other and with relevant intergovernmental organizations and other entities, as appropriate, to achieve the objectives of this Article. Such cooperation may include:

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132. Telmer & Persaud, *supra* note 2, at 18C-8.

133. *Id.*

134. Conference of Plenipotentiaries on the Minamata Convention on Mercury, Kumamoto, Japan, Oct. 10-11, 2013, *Final Act of the Conference of Plenipotentiaries on the Minamata Convention on Mercury*, UNEP(DTIE)/Hg/CONF/4 [hereinafter *Minamata Convention on Mercury*].

135. *Id.* art. 7, ¶ 1, 2.

136. "Parties" refers to each state that is a member to the Convention.

> (a) Development of strategies to prevent the diversion of mercury or mercury compounds for use in . . . small-scale gold mining and processing;
>
> (b) Education, outreach and capacity-building initiatives;
>
> (c) Promotion of research into sustainable non-mercury alternative practices;
>
> (d) Provision of technical and financial assistance;
>
> (e) Partnerships to assist in the implementation of their commitments under this Article; [and]
>
> (f) Use of existing information exchange mechanisms to promote knowledge, best environmental practices and alternative technologies that are environmentally, technically, socially and economically viable.[137]

The Treaty also addresses the importance of educating the small-scale miners on different materials that will provide them with information that will promote mercury-free mining operations, or at least operations where mercury is recycled and prevented from entering into the environment. The Treaty states:

> Each Party shall, within its capabilities, promote and facilitate:
>
> (a) Provision to the public of available information on:
>
> (i) The health and environmental effects of mercury and mercury compounds;
>
> (ii) Alternatives to mercury and mercury compounds;
>
> (iii) [scientific information concerning mercury and mercury compounds, including toxicological and ecotoxicological information]

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137. *Minamata Convention on Mercury*, art. 7, ¶ 4.

> (iv) The results of its research, development and monitoring activities . . . ; and
>
> (v) Activities to meet its obligations under this Convention;
>
> (b) Education, training and public awareness related to the effects of exposure to mercury and mercury compounds on human health and the environment in collaboration with relevant intergovernmental and non-governmental organizations and vulnerable populations, as appropriate.[138]

These measures will provide a broad framework to guide the Amazon Governments in providing materials to educate the small-scale miners. Along with this framework, each Amazon Government will need to take into account all concerns that were discussed above as training programs should be designed with specific communities in mind.

The Treaty also addresses provision that call for funding to be funneled, through domestic means, into small-scale mining. The Treaty states that "[e]ach Party[shall] undertake to provide, within its capabilities, . . . domestic funding through relevant policies, development strategies and national budgets, and bilateral and multilateral funding, as well as private sector involvement."[139] Also, "developed" countries are encouraged to provide financial and technical assistance, as well as "capacity-building and technology transfer . . . to enhance and increase their activities on mercury in support of developing country Parties," a group that includes all of the Amazon Countries.[140] Again, this assistance can provide necessary funding, but it should be used to provide small-scale miners with the funding needed to make improvements to their equipment that will allow them to stop using mercury, or at least limit the amount of mercury being used. These changes may come by providing the miners with credit, or equipment such as retorts could be purchased and distributed to the miners, so long as the miners are trained on how to

138. *Id.* art. 18, ¶ 1.
139. *Id.* art. 13, ¶ 1.
140. *Id.* art. 13, ¶ 3.

use the equipment and convinced to use it, however that may be accomplished.

The Treaty will also provide "a [m]echanism for the provision of adequate, predictable, and timely financial support [to] developing country Parties and Parties with economies in transition in implementing their obligations under this Convention,"[141] which shall be provided through one of two different "mechanisms." These mechanisms include: "(a) The Global Environment Facility Trust Fund;[142] and (b) A specific international Programme to support capacity-building and technical assistance."[143] These programs will funnel monetary assistance into the areas where the populations living around the mining activities are most at risk.

Along with financial assistance, the "developed" countries "shall cooperate to provide, within their respective capabilities, timely and appropriate capacity-building and technical assistance to developing country Parties, . . . and Parties with economies in transition, to assist them in implementing their obligations under this Convention." These

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141. *Id.* art. 13, ¶ 5.

142. *Id.* art. 13, ¶ 7 ("The Global Environment Facility Trust Fund shall provide new, predictable, adequate and timely financial resources to meet costs in support of implementation of this Convention as agreed by the Conference of the Parties. For the purposes of this Convention, the Global Environment Facility Trust Fund shall be operated under the guidance of and be accountable to the Conference of the Parties. The Conference of the Parties shall provide guidance on overall strategies, policies, programme priorities and eligibility for access to and utilization of financial resources. In addition, the Conference of the Parties shall provide guidance on an indicative list of categories of activities that could receive support from the Global Environment Facility Trust Fund. The Global Environment Facility Trust Fund shall provide resources to meet the agreed incremental costs of global environmental benefits and the agreed full costs of some enabling activities. In providing resources for an activity, the Global Environment Facility Trust Fund should take into account the potential mercury reductions of a proposed activity relative to its costs.").

143. *Id.* art. 13, ¶ 5, 9 ("For the purposes of this Convention, the Programme referred to in paragraph 6 (b) will be operated under the guidance of and be accountable to the Conference of the Parties. The Conference of the Parties shall, at its first meeting, decide on the hosting institution for the Programme, which shall be an existing entity, and provide guidance to it, including on its duration. All Parties and other relevant stakeholders are invited to provide financial resources to the Programme, on a voluntary basis.").

technologies "may be delivered through regional, subregional and national arrangements, including existing regional and subregional centres, [sic] through other multilateral and bilateral means, and through partnerships, including partnerships involving the private sector."[144]

2. Limiting the Supply of Mercury

The Treaty is also designed to reduce the amount of available mercury through measures that will limit the available supply of mercury in the marketplace. Mercury will be limited by making sure that new mercury mines are not allowed in any country that is a member to the Minamata Convention. The Treaty states that "[e]ach Party shall not allow primary mercury mining that was not being conducted within its territory at the date of entry into force of the Convention for it."[145] The Treaty also asks that all members close any mines that are open when the Treaty enters into force to be closed within fifteen years after that date.[146] These provisions will limit the amount of mercury that goes into the marketplace, which may cause the price of mercury to increase to the point where it is no longer economically possible for the miners to be able to afford mercury. If this happens, the small-scale miners may be forced to adopt alternative recovery processes.

The Treaty will not stop at limiting the supply of new mercury sources. It will also aim to decrease the amount of existing mercury by requiring all members to:

> (a) endeavor to identify individual stocks of mercury or mercury compounds exceeding 50 metric tons, as well as sources of mercury supply generating stocks exceeding 10 metric tons per year, that are located within its territory; and (b) take measures to ensure that, where [there is an excess of mercury available, it is] disposed of in accordance with the guidelines for environmentally sound management.[147]

144. *Id.* art. 14, ¶ 2.
145. *Id.* art. 3, ¶ 3.
146. *Id.* art. 3, ¶ 4.
147. *Id.* art. 3, ¶ 5.

With the amount of countries that have signed onto the Convention the amount of mercury available in the marketplace should be significantly reduced. With these reductions, small-scale miners may have a difficult time finding enough mercury to continue to use amalgamation. At the very least it may cause the miners to switch from whole ore amalgamation to amalgamation by gravity concentrates because so much mercury is lost, compared to the amount of gold recovered, in the former process.

3. Limiting the Trade of Mercury

The European Union enacted an export ban beginning in 2011, and in 2008, the United States Congress enacted a similar export ban beginning in 2013.[148] The Treaty follows the example set in the European Union and United States by limiting all import and export of mercury for all members of the Treaty. The treaty does provide for exceptions to the limitations on trade, but these exceptions are only allowed in limited circumstances. The Treaty states that "[e]ach Party shall not allow the export of mercury" except in certain situation outlined in the Treaty.[149] The exact language in the Treaty provides that:

The exceptions include:

> (a) To a Party that has provided the exporting Party with its written consent, and only for the purpose of:
>
> (i) A use allowed to the importing Party under this Convention; or
>
> (ii) Environmentally sound interim storage . . . ; or
>
> (b) To a non-Party that has provided the exporting Party with its written consent, including certification demonstrating that:
>
> (i) The non-Party has measures in place to ensure the protection of human health and the environment . . . ; and

148. NATIONAL RESOURCES DEFENSE COUNCIL, *supra* note 127.
149. *Minamata Convention on Mercury*, art. 3, ¶ 6.

> (ii) Such mercury will be used only for a use allowed to a Party under this Convention or for environmentally sound interim storage.[150]

The Treaty also allows for the "import of mercury from a non-Party to whom it will provide its written consent unless the non-Party has provided certification that the mercury is not from sources identified as not allowed" under the provisions of the Treaty.[151] This provision will allow members of the Treaty to further limit the amount of mercury that small-scale miners will be able to access because imported mercury will be used in a way that limits the dangers of using mercury.

The convention will go into force 90 days after 50 states ratify the Treaty. Currently the only country that has ratified the Treaty is the United States. While the 95 other signatories of the Treaty have agreed to follow the treaty, even without ratification, more states need to follow the example of the United States and ratify the treaty so that it goes into force. Upon going into force, the Treaty will not only shape international policies and actions, it will also represent international disapproval of using mercury in ways that may be hazardous, such as small-scale mining.

CONCLUSION

Small-scale miners use mercury because it is one of the most inexpensive and efficient methods of recovering gold. The problem with using mercury is that it poisons the miners, who are using it because of its economic advantages, and surrounding communities. It may be difficult to convince small-scale miners to abandon mercury amalgamation but the small-scale miners may be convinced through custom training and educational programs when accompanied with technical and financial assistance that are provided from many different sources. These custom programs should be more successful than previous programs have been, so long as they take into account anthropological components, which has largely been ignored in the past.

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150. *Id.* art. 3, ¶ 6.
151. *Id.* art. 3, ¶ 8.

Whether at the local level or international level, changes need to be made to ensure that people do not suffer the same fate as those in Minamata, Japan.