The Adequacy of Polychlorinated Naphthalenes Listing Under the Hong Kong Convention

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Ship demolition practices continue to face substantial environmental, social, and regulatory challenges demanding attention. A pivotal development in this domain was the enforcement of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention), which entered into force on June 26, 2025. Given that the Convention was adopted in 2009, there is a need to evaluate whether its provisions on hazardous materials remain adequate. Polychlorinated naphthalenes (PCNs) are currently listed in Appendix 2 to the Hong Kong Convention as hazardous materials having potentially significant adverse effects on human health and the environment. This policy-driven narrative review examines whether the current regulatory treatment of PCNs adequately safeguards human health and the environment. Guided by this policy-relevant question, this review synthesizes and analyzes recent scientific evidence and ship recycling practices. The analyses conducted identified a significant knowledge gap and factors impeding accurate risk assessment. Consequently, this paper recommends further policy consideration of the potential benefits of reclassifying PCNs from Appendix 2 to Appendix 1 (materials whose use or installation is prohibited) to strengthen their environmental management.

KEY WORDS
~ Ship recycling
~ Hong Kong convention
~ Polychlorinated naphthalenes
~ Inventory of hazardous materials
~ Environmental impact of shipping
~ Environmental contaminants

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1. INTRODUCTION

When conducted responsibly, ship recycling is a highly sustainable process that aligns with the principles of a circular economy by minimizing waste and maximizing resource recovery. In addition to conserving energy and natural resources, it also supports employment, particularly in developing regions (IMO, 2025).

Although ship recycling is fundamentally sound, working conditions and environmental standards in many yards have long been inadequate and continue to fall short. To address these issues, the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention) was adopted in 2009. However, its entry into force was delayed due to limited early support from major shipbreaking nations, resistance from ship-owning countries, slow infrastructure development, and broader political and economic factors (Pozdnakova, 2024). After years of persistent efforts by key stakeholders, it took effect on June 26, 2025 (IMO, 2025).

To comply with its requirements, vessels must have, regularly update, and keep an Inventory of Hazardous Materials (IHM). This document must remain current throughout the ship’s service life, ensuring that any changes in hazardous materials on board are accurately recorded (Hong Kong Convention, 2009). Part I of the IHM includes materials listed in Appendix I (13 materials from 4 categories whose installation or use is prohibited and/or restricted in shipbuilding) and Appendix II (nine hazardous materials likely to cause significant adverse effects on human health or the environment).

In light of advancements in scientific knowledge, the identification of newly recognized harmful substances, evolving technological and industrial landscapes, international harmonization efforts, policy alignment, adherence to global agreements, and improvements in recycling technologies and practices, amendments to Appendix 1 and/or Appendix 2 may be proposed as outlined in Regulation 6 (Hong Kong Convention, 2009). Such proposals are subject to a review process that involves a comprehensive assessment of the hazardous material's potential to cause significant adverse effects on human health or the environment, an evaluation of the risk reduction achievable through the proposed control measures and any supplementary actions, and an analysis of the technical feasibility of implementing these measures. Additionally, the broader impacts of the control measures on the environment, human health (including seafarers and workers), as well as their economic implications for international shipping and related industries are carefully considered. Alternatives to hazardous substance must be examined, and the risks associated with these alternatives and their potential impact during recycling assessed. Furthermore, the process involves determining appropriate threshold values and necessary exemptions to ensure a balanced and effective regulatory approach.

To date, the only update to Appendix 1 to the Hong Kong Convention has been the inclusion of cybutryne, in keeping with an amendment to Annex 1 to the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 (MEPC, 2023). However, significant regulatory developments concerning other IHM substances have occurred under international treaties since 2009. Specifically, polychlorinated naphthalenes (PCNs), listed for elimination under Annex A to the Stockholm Convention since 2015, are still permitted for onboard use in keeping with Appendix 2 to the Hong Kong Convention. This discrepancy creates a potential regulatory gap that merits further examination. Consequently, it is advisable to assess whether amendments to the Hong Kong Convention are necessary to address this deviation from the Stockholm Convention.

This paper provides an overview and analysis of recent research and prevailing ship recycling practices to support informed decision-making. Therefore, a policy-driven narrative review approach was adopted to evaluate the adequacy of the current listing of PCNs under the Hong Kong Convention, with a focus on recent findings concerning the risk profile of PCNs. Relevant literature was identified through searches of the scientific databases Scopus and Web of Science from December 2024 to February 2025. Peer-reviewed papers were selected using keywords “PCNs”, “toxicity”, “health risk assessment”, “environmental impact”, and “ship recycling.” Priority was given to all types of review papers (narrative, scoping and systematic) published within the last five years or, if unavailable, to the most recent review on the topic. In addition, original research papers published after the selected reviews and addressing the same research questions were included. Additional sources were incorporated when they provided relevant background information or essential clarification necessary for comprehensive interpretation. Papers not directly related to the topic, publications preceding the selected review papers (unless essential for the context), and sources with limited relevance were excluded. The included literature was critically analyzed and synthesized to identify key topics and gaps in current knowledge. Based on the analysis of recent scientific data on environmental and human health risks of PCNs and the consequences of prevailing ship-recycling practices, this paper aims to inform and support the examination by the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) of whether the current treatment of PCNs in Appendix 2 to the Convention remains appropriate within the framework of the Hong Kong Convention.

2. SOURCES AND ENVIRONMENTAL OCCURRENCE OF POLYCHLORINATED NAPHTHALENES

Chlorinated naphthalenes (CNs) are characterized by the substitution of any or all of the eight hydrogen atoms in the naphthalene molecule with chlorine atoms (Environment Canada, 2011). The full range of chlorinated naphthalenes, including mono-CN congeners, consists of 75 distinct compounds with the molecular formula $C10H8-(m+n)Cl(m+n)$ (Figure 1), organized into eight homologue groups, spanning from mono-chlorinated to octachlorinated derivatives. The term “CNs” more accurately refers to the entire class of chlorinated naphthalenes, while the term “PCN” excludes the two mono-CNs, consistent with the listing in Annexes A and C to the Stockholm Convention of 2015. However, in the literature, “PCNs” is often used to refer to all CNs (CAS RN 70776-03-3), including the mono-CN congeners. Therefore, “PCNs” will be used in this paper in line with the prevailing scholarly practice.

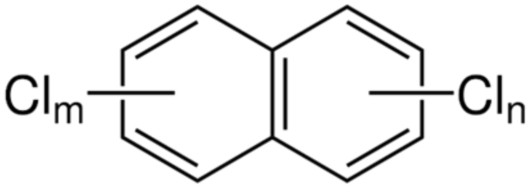

Figure 1. Generic structure of PCNs

The physical and chemical properties of PCN congeners are primarily determined by the number of chlorine atoms in the molecule, with their specific positions having a secondary role. Their chemical and thermal stability, low flammability, hydrophobicity, water resistance, dielectric properties and plasticizing and lubricating abilities enabled use in various industrial applications. Between 1910 and 1980, PCNs were commercially manufactured as mixtures of different homologue groups for a wide range of applications (Environment Canada, 2011). Mono-PCNs and mixtures of mono- and di-PCNs have been used in chemical-resistant gauge fluids, instrument seals, heat exchange fluids, high-boiling-point solvents, color dispersions, engine additives, and motor tune-up compounds. Mono-PCNs also served as raw materials for dyes and wood preservatives. Tri- and higher-chlorinated PCNs have been used in the electronics and automotive industries for impregnating condensers, capacitors, and encapsulating compounds, as well as in ceramic manufacturing, paper coating, alloy casting, electroplating, gear oils, cutting fluids, flameproofing, insulation, moisture-proof sealants, battery separators, refractive oils, and grinding wheel lubricants. PCN production was primarily concentrated in Germany, the United Kingdom, France, Italy, Poland, the United States, the Soviet Union, and Japan. Efforts to estimate total global production have been ongoing for inventory and regulatory purposes, but precise data remain elusive (Klimczak et al., 2023). In many cases, records of past PCN production are either completely unavailable or difficult to access, regardless of country or manufacturer. Early estimates suggest that total global production ranged from 150,000 to 400,000 metric tons. Available data indicate that production peaked between the 1930s and 1950s. However, their production began to decline in the following decades and largely ceased by the 1980s, primarily due to voluntary discontinuation by major producers in response to growing environmental and health concerns. Although PCN production effectively ended by the 1980s, they remained in industrial use for another decade, with some formulations stockpiled until the late 20th century (Yamamoto, Noma and Sakai, 2018).

The primary sources of PCNs are human-induced, including past production and use, unintended releases from industrial activities, and contamination from commercial PCB mixtures and other chemical products (Luo et al., 2024). Small quantities of PCNs can also be emitted through natural processes such as wildfires. Since PCNs and PCBs are no longer produced or used, current PCN emissions are mostly unintentional, occurring through various industrial processes, including municipal solid waste incineration, iron ore sintering, and secondary copper smelting. A study published in 2024 estimated historical PCN emissions from production and use between 1912 and 1987, as well as unintentional emissions from 20 sources between 2000 and 2020 (Luo et al., 2024). The results show that historical production led to the release of 468,014 metric tons of PCNs, with 96.6% occurring during product use. Between 2000 and 2020, total unintentional emissions amounted to 11,534 metric tons. In 2020, global PCN emissions were estimated at 293.5 metric tons (15.8 kg Toxic Equivalent, TEQ), with municipal waste incineration accounting for 98.0% of total emissions. West Central Asia was identified as the largest emission region. According to the authors, future PCN emissions may fluctuate significantly, with projections ranging from a 29% decrease to a potential 347% increase.

The atmosphere is the main receptor for PCN emissions, transporting them over large distances before they are deposited into different environmental compartments, including soil, water, sediments, and living organisms, as shown by reviews published in 2020 (Agunbiade et al., 2020) and 2022 (Nevondo and Okonkwo, 2022). Recent studies demonstrated that PCNs have reached remote areas such as the Arctic and Antarctica (Dong et al., 2023; Gebru et al., 2023, 2024). Most recent studies on atmospheric PCN concentrations have mostly been conducted in areas with poor air quality and/or influenced by combustion and industrial activities (Mao et al., 2020; Nguyen et al., 2021; Xu et al., 2021; Yang et al., 2021, 2022; A et al., 2022; Maceira, Borrull and Marce, 2022; Thuan et al., 2024). As pointed out by Nevondo and Okonkwo (Nevondo and Okonkwo, 2022), the atmosphere in locations with poor waste handling may contain elevated PCN levels and should be prioritized for monitoring. Industrial activities, such as e-waste recycling (Niu et al., 2021), cement kiln co-processing, metal smelting (Xu et al., 2020), treatment of municipal and medical wastes (Han et al., 2022; Nigar et al., 2024), and wastewater treatment (Die et al., 2021) may also result in soil contamination.

Consistent with previous studies, recent data indicate that PCNs tend to accumulate in both marine and freshwater environments, as shown by research on water and sediment samples from various locations, including the Markman Canal in South Africa (Agunbiade et al., 2023), the Yangtze River Delta (Liu et al., 2021; Lei et al., 2022), the Chaobai River, an important drinking water source in China (Du et al., 2022), highly industrialized bays in South Korea (Lee et al., 2021, 2023; Son et al., 2024) and three major rivers in South Korea (Choo et al., 2020). Research on levels in biota has also been published in the last five years, with studies reporting the occurrence of PCNs in various biotic samples, including insects (Qi et al., 2022), fish (Pagano and Garner, 2020, 2021; Pagano et al., 2021), bird eggs (Viluksela et al., 2024), and mammals (Dominique et al., 2020; Desforges et al., 2024; Pereira et al., 2024) primarily due to absorption through contact with contaminated water, soil, or air, as well as bioaccumulation and biomagnification through the food chain. A study that investigated Antarctic fauna samples demonstrated extensive pollution and food chain distribution of PCNs (Kim et al., 2021). Regardless of the environmental matrix studied, recent studies indicate that spatial trends show a decline in PCN levels. Most recent studies also suggest that while contamination is present, the levels observed are not of significant concern. However, the lack of recent PCN research in many developing and underdeveloped countries is evident, with few or no studies available, preventing conclusions about the presence and potential harm of PCNs.

3. HUMAN HEALTH AND ENVIRONMENTAL CONSEQUENCES OF POLYCHLORINATED NAPHTHALENES

Exposure to PCNs through ingestion, inhalation, and skin contact has been linked to a range of adverse biological effects, with severity varying depending on the level of exposure (IPCS, 2001). In occupational settings in early to mid-20th century, workers exposed to PCNs experienced severe skin reactions and liver damage, which in some cases led to death. Other reported symptoms included eye irritation, fatigue, headaches, anemia, hematuria, impotence, anorexia, nausea, vomiting, and severe abdominal pain. Incidental exposure of the general population to PCNs was uncommon and occurred before the widespread recognition of the toxic risks associated with these compounds. Currently, chronic exposure to PCNs, primarily through dietary intake, is a greater concern for the general population than other sources due to the banning of PCN use and stricter atmospheric emission control (Fernandes, Rose and Falandysz, 2017).

PCNs have been detected in various tissues, organs and bodily fluids (including milk) of both animals and humans, with their distribution influenced by exposure levels, metabolic processes, and tissue lipid content. Due to their lipophilic nature and the reduced likelihood of hydroxylation in highly chlorinated PCN congeners, they primarily accumulate in adipose tissue and the liver, with higher retention observed for congeners containing four or more chlorine atoms (Chen et al., 2023). Among human body burden monitoring samples, breast milk has been studied in the greatest number of countries. A study of human milk samples from 39 countries found varying levels of PCN concentrations, with Europe having significantly higher levels due to historical PCN production and use (Tschiggfrei et al., 2023).

The toxicological effects of PCNs were thoroughly reviewed by Fernandes et al. (2022). This section summarizes the main findings; a comprehensive analysis of the data, including methodological considerations, is available in the original publication (Fernandes et al., 2022). PCNs, particularly hexa-PCNs, activate the aryl hydrocarbon receptor (AhR), causing toxicity in various organs. In the liver, they can cause damage such as fatty liver, hepatomegaly, and necrosis. The brain is also affected, leading to neuropsychological issues and impairments in neurotransmitter processes, motoric activity, and memory. PCNs disrupt the endocrine system, causing thymic atrophy, reproductive problems, and changes in blood parameters. They can also affect fetal development, causing growth delays, organ malformations, and developmental defects. Additionally, PCNs interfere with sex hormone and thyroid signaling, leading to potential fertility and hormonal problems.

Dietary intake was identified as the primary source of human PCN exposure, and numerous studies have investigated their presence in various foods, including fish and seafood, meat and meat products, eggs, animal and vegetable fats and oils, as well as vegetables and vegetable-based products (Domingo, 2024). A review published in 2024 (Domingo, 2024) concluded that existing data indicate a downward trend in PCN levels in food, suggesting that associated risks are not significant. However, the author highlighted that data on the total daily dietary intake of PCNs is limited (there is a total absence of available scientific publications in American countries, including the USA, Canada, Mexico, or Brazil, for example), as most studies have concentrated on estimating exposure through specific food categories, such as fish and seafood, milk, and meats. Moreover, a notable gap in research exists in other relevant countries such as India, Australia, Japan, and all African nations. Additionally, exposure assessment is limited by the fact that many individual studies investigated only a fraction of the 75 possible congeners, and the majority of congeners were analyzed in only a small number of studies. The European Food Safety Authority (EFSA) evaluated the potential health risks of PCNs in food and feed in 2024, focusing mainly on hexa-PCNs due to limited data on other congeners (Schrenk et al., 2024). The assessment found that exposure levels for the general population and breastfed infants were below risk thresholds, suggesting no health risk from dietary hexa-PCN exposure. However, due to data gaps, the evaluation could not assess genotoxic effects or the risks of other PCNs, and an acceptable daily intake value was not established.

Compared to dietary sources, the risk of PCN exposure from non-dietary sources has been less studied since 2020. All studies reviewed here were conducted in Asian countries (predominantly China), with majority focusing on various industrial processes (Table 1).

Sample/exposure pathway	Sampling area	Number of PCN congeners investigated and concentration range detected	Estimated risk level	Reference
Particulate matter/inhalation	City of Dalian, China	17; 0.05-1.42 pg/m^3	Low	(Mila et al., 2022)
Air samples/inhalation	Suburban and urban areas, Ho Chi Minh City, Vietnam	75; 12.9-263 pg/m^3	Low	(Thuan et al., 2024)
Particulate matter/inhalation	Vicinity of secondary copper smelters, Shandong Province, China	75; 4.76-9.89 pg/m^3	Low	(Yang et al., 2021)
Soil/soil ingestion, inhalation, dermal contact, and dietary ingestion	E-waste recycling area, Guiyu, China	18; 1.22×10^3 ng/g-2.71×10^5 ng/g	High	(Niu et al., 2021)
Soil/ingestion, dermal contact, and inhalation	Industrial park located in Ningxia Province, China	75; 183-3340 pg/g	Medium	(Xu et al., 2020)
Soil/ingestion, inhalation, dermal contact	Around a cement kiln co-processing municipal wastes, Northwestern China	75; 138-1288 (pg/g)	Low	(Han et al., 2022)
Soil/ingestion, inhalation, dermal contact	Dumpsites, e-waste, and industrial areas in Dhaka, Bangladesh	50; 0.632-66.7 ng/g	Low	(Nigar et al., 2024)
Indoor air and dust	Areas nearby E-waste hubs, cities Karachi, Lahore, Peshawar, Rawalpindi and Gujranwala, Pakistan	39; 7.0-9583 pg/m^3 (air), 0.25-697 ng/g (dust)	Medium (based on TEQ values)	(Waheed et al., 2020)

Table 1. Human health risk from PCN exposure through non-dietary sources.

Similarly to studies on food, the majority of studies suggest that associated risks are not significant. On the contrary, a study that measured PCN levels in agricultural soil from an e-waste recycling area and assessed multiple exposure pathways (soil ingestion, inhalation, dermal contact, and dietary ingestion) indicated that residents faced a high cancer risk (Niu et al., 2021). Among the four age groups, toddlers showed the highest susceptibility to cancer risks, followed by children, teenagers, and adults. Across all age groups, the Incremental Lifetime Cancer Risk contribution from dietary ingestion was approximately 3 to 10 times higher than that of other exposure pathways. For most age groups, dermal contact was the second most significant exposure route. However, for toddlers, soil ingestion and dermal contact contributed equally to risk. A study investigating human health risks due to exposure to PCDD/Fs, PCNs, and PCBs present in soil from an area affected by various industrial processes found that carcinogenic risks for workers should receive more attention (Xu et al., 2020). The results of these two studies indicate that evaluating all exposure pathways for all present contaminants may be required to ensure a thorough understanding of potential health and environmental risks. Only one study investigated PCN concentrations in indoor air, dust, and human serum. Elevated TEQ values indicated possible human health issues for workers, residents and children (Waheed et al., 2020).

4. DISCUSSION AND RECOMMENDATION

The Hong Kong Convention adopts a "cradle-to-grave" approach to the life cycle of a ship. Regarding hazardous materials, it promotes responsible design, construction, maintenance, and recycling of ships by prohibiting or restricting the use of materials listed in Appendix 1 and requiring the identification of the quantity and location of materials listed in Appendix 2 (Hong Kong Convention, 2009). However, compliance with the Hong Kong Convention differs significantly between new and existing ships. While the current inclusion of PCNs in Appendix 2 technically allows their use in new ships, this is effectively irrelevant since PCN production and use have ceased. The main concern is ship recycling. Namely, existing ships are required to establish an IHM within five years of Convention's entry into force, or before being sent for recycling, whichever comes first. However, once the IHM becomes mandatory, materials listed in Appendix 2 are not required to be included in the inventory. As a result, existing ships can be dismantled without tracking PCN location or quantity, and the regulation inadvertently permits their uncontrolled release and improper management. This is problematic for several reasons.

The global shipping fleet is ageing, with numerous vessels nearing the end of their service life (approx. 40 % of ships are older than 20 years) as reported by the United Nations Conference on Trade and Development in 2024 (UNCTAD, 2024). In recent years, ship recycling activity has remained low. Older vessels have been used to take advantage of disruptions in shipping routes and inflated freight rates. Ongoing uncertainty about future regulatory policies and low-carbon ship technologies and fuels also played a role. However, environmental targets introduced by the International Maritime Organization (IMO) and other relevant regulatory bodies are becoming stricter. Therefore, the rate of ship recycling is expected to increase in the coming years as pressure mounts to renew the global fleet (UNCTAD, 2024).

The global shortage of compliant ship recycling facilities, combined with the increased costs for shipowners associated with their use, suggests that the current trend of sending the majority of ships worldwide to Bangladesh, India, and Pakistan (80% and 85% of global tonnage in 2024 and 2023, respectively) for recycling by the open-beaching method is likely to continue (Mulinaris, 2025). This method, which has been used for years, has resulted in a continuous influx of hazardous materials, including asbestos, glass wool, PCBs, heavy metals, polyaromatic hydrocarbons, hydrocarbons, and organotin compounds into the environment, leading to significant environmental degradation. The contamination of air, soil, and water by various pollutants has severely impacted marine and coastal ecosystems (Barua et al., 2018). Detrimental impacts on human health and well-being caused by these pollutants have also been observed (Moussa et al., 2024). However, many stakeholders seem to have accepted the trade-off between economic development and environmental well-being (Dewan, 2020).

Under these conditions, recycling of old ships by the open-beaching method, not explicitly banned by the Hong Kong Convention (ratified by Bangladesh, India, and Pakistan), could potentially result in PCN emissions into an environment already burdened with various chemicals, highlighting the need for a risk assessment. However, an accurate risk assessment is hampered by a knowledge gap identified by this research. As far as the author is aware, there is no published data regarding the levels of PCNs in the environment surrounding shipbreaking yards. Nevertheless, their presence could be expected due to activities such as scraping or burning paint off the ship surface, dumping and reselling lubricating oils, and improper management of obsolete PCN or PCB-containing equipment that was frequently deposited in landfills. Additionally, emissions from other industrial activities that take place near yards are another potential source of PCNs (Nøst et al., 2015). Therefore, research on PCN levels in shipbreaking areas is needed as the first step in a risk assessment process.

Furthermore, a thorough, long-term sampling of all relevant matrices, along with a multi-pathway health risk assessment, is essential to ensure that risks are accurately assessed and not underestimated. As mentioned in the previous section, a comprehensive toxicity study of all PCN congeners is also needed. Additionally, chemicals with a common toxic mode of action must be included, particularly dioxin-like contaminants. However, research on levels of organic contaminants in air, water, sediments and soils from shipbreaking is limited. Published studies have found elevated levels of PAHs, SCCPs, hexachlorobenzene (HCB) and PCBs that may pose a risk to human health (Nøst et al., 2015; Ai et al., 2022; Goswami et al., 2023; Shakoor Khan et al., 2024; Uddin and Xu, 2024).

Given the complex nature of the required analyses, it is unlikely that all necessary research can be completed in the near future. However, the countries that have signed and ratified the Hong Kong Convention acknowledge and intend to apply the precautionary principle, meaning that, despite scientific uncertainty, reasonable and proportionate measures should be taken to mitigate potential risks (Hong Kong Convention, 2009).

The literature analysis conducted in this study indicates that the inherent hazards associated with the presence of PCNs on board ships are not yet fully investigated or understood. Nevertheless, recent scientific evidence confirms that PCNs are persistent, bioaccumulative, and toxic, the very properties that formed the basis for their ban under the Stockholm Convention, despite a lack of full scientific certainty. The Stockholm Convention evaluation process involves extensive expert review of hazard, exposure, and long-range transport, and therefore represents a high-confidence regulatory assessment. Therefore, a revision toward more stringent regulatory measures related to ship recycling is considered necessary to align with the established precautionary principle. This conclusion is well-supported despite certain methodological constraints. Specifically, the study was restricted to English-language publications, potentially excluding relevant non-English research. Furthermore, a formal methodological quality appraisal was omitted, consistent with the methodology often employed for narrative state-of-the-art reviews. However, the potential impact of these limitations is mitigated by the extensive breadth of the analysis, which involved a substantial body of peer-reviewed literature, including recent scoping and systematic reviews.

Therefore, it is recommended that the expert panel designated by the MEPC evaluate the reclassification of PCNs, specifically advocating for their inclusion in Appendix I rather than Appendix II of the Hong Kong Convention. Adherence to the requirements stipulated for Appendix I materials is critical for minimizing the risk of PCN emissions during ship recycling, as it mandates the controlled removal and proper disposal of PCN-containing materials. This reclassification would establish a more robust and commensurate framework for managing PCNs, accurately reflecting their environmental and health risks.

The inclusion of PCNs in Appendix I presents a challenge for ship owners. However, given that Stockholm Convention parties must create PCN inventories, and supporting documents are available, the process is more manageable, and the proposed reclassification of PCNs under the Hong Kong Convention appears to be a reasonable approach.

Moreover, while all major ship recycling countries (Bangladesh, India, Pakistan, China, and Turkey) have ratified the Stockholm Convention, significant implementation challenges remain, including a lack of public awareness. Reclassifying PCNs under the Hong Kong Convention could help address this gap and strengthen overall efforts to control these harmful substances.

5. CONCLUSIONS

Due to their historical use, PCNs are global environmental contaminants associated with various adverse effects in humans and animals. Despite growing awareness, the risks associated with PCN exposure remain incompletely understood. Further research is needed to address critical knowledge gaps, including their levels in different environmental compartments, mechanisms of toxicity, and potential health outcomes. Additionally, more comprehensive studies are needed to assess human exposure pathways and the effects of long-term, low-level exposure. Improved understanding of these factors is essential for accurate risk characterization. The process of risk characterization related to the possible unintentional release of PCNs during ship dismantling is further complicated by significant levels of other contaminants present, which may have a synergistic effect. Furthermore, effective risk assessment requires adequate funding, specialized laboratories, and skilled professionals, resources that are lacking in countries where ship recycling is predominantly conducted.

The Hong Kong Convention permits the restriction or prohibition of hazardous substances based on the precautionary principle, even without comprehensive empirical data on exposure risks specific to ship-recycling activities. In such cases, regulatory action is justified by the intrinsic hazardous properties of the substances and by evidence from similar occupational or environmental contexts. The text of the Hong Kong Convention states, “If the technical group finds that the Hazardous Material in question is likely, in the context of this Convention, to lead to significant adverse effects on human health or the environment, lack of full scientific certainty shall not be used as a reason to prevent the group from proceeding with an evaluation of the proposal”. Therefore, the scientific validation provided by the Stockholm Convention listing, and the peer-reviewed literature analyzed in this paper support the conclusion that sufficient evidence exists to justify initiating a new MEPC review process, even without comprehensive ship-recycling-specific exposure data.

The IHM is essential for safe and environmentally sound ship recycling, as it identifies the type, location, and quantity of hazardous substances on board. However, the Hong Kong Convention requires that for existing ships, only materials listed in Appendix 1 must be included in the IHM, while substances in Appendix 2 should be included only to the extent practicable. Given current and anticipated future realities in ship recycling, the identification of PCNs in the IHM is not expected, as it is not strictly mandated. Listing PCNs in Appendix 1 rather than Appendix 2 of the Hong Kong Convention would enhance risk management during ship dismantling by enabling more stringent control measures, thereby reducing environmental and occupational hazards. Such a change would provide a clearer regulatory framework for identifying, managing, and removing PCNs, thereby supporting safer recycling practices.

One reason cited in Regulation 6 for initiating amendments to the list of substances covered by the Hong Kong Convention is the need for policy alignment. PCNs were banned by the Stockholm Convention in 2012, three years after the adoption of the Hong Kong Convention, and their treatment differs significantly, as the Hong Kong Convention does not prohibit their use on board ships. Alignment with the Stockholm Convention would strengthen regulatory coherence and contribute to its broader implementation, reinforcing international efforts to minimize the risks associated with PCNs.

CONFLICT OF INTEREST

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