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SECRETS OF THE ARCTIC

Monitoring Methane Gas Emissions' Effects on Human Rights

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Abstract

In the Arctic, methane emitted from thawing permafrost have reached alarming levels, surpassing 1.950 parts per billion over the last 5 years, which is significantly higher than pre-industrial levels (UNEP, 2021). The gradual and cumulative effects of methane-induced climate change can contribute to the erosion of Arctic Indigenous communities' well-being (ECHO, 2023, WHO, 2015), disrupt ecosystems (Bhatia et al., 2012, IDNR, 2023), exacerbate environmental inequalities, and perpetuate social injustices (CCAC, 2021) over time. These indirect impacts align with the underlying principles of slow violence. Methane emissions in the Arctic can be understood as committing a violent act against the global population. This study aims to emphasize the crucial potential and indirect connections between methane emissions, slow violence and their impact on human rights. By connecting the intensification of climate change resulting from increased methane emissions to the concept of slow violence, we can better understand the gradual devastation faced by communities.

To answer the research questions, remotely sensed satellite data was used to examine the impacts of methane emissions and its outcome on air quality, also called a spectroscopic analysis, which determines the chemical constitution of substances. Remote sensing is a useful tool, as the derived information can provide insight into how toxic gasses directly affect the air quality and indirectly leads to changes in human health (CCAC, 2021, Bermann, 2023, Gorrono, 2022).

The results include: Methane contributes to the growing global concentration of tropospheric ozone, an air pollutant associated with cancer in humans and premature deaths when exposed to it long-term (Kim, et al., 2018, West, et al., 2006). The Arctic Indigenous communities have been found to hold more cancer cells of different kinds than their non-Indigenous fellow citizens. There has been marked an increase in lung, colorectal and female breast cancers, as well as some rare cancers such as nasopharyngeal cancer (Young, et al., 2016). Breathing ozone can shorten the lives of people in higher risk groups such as Indigenous Peoples. Researchers have repeatedly found that the risk of premature deaths increased with higher levels of ozone (Kim, et al., 2018).

Key words: Methane emissions, slow violence, environmental degradation, Indigenous rights, Indigenous health, remote sensing, human rights, toxic pollution

List of abbreviations

API	Application Programme Interface
C	Carbon
CH_4	Chemical formula of methane: 1 Carbon, 4 Hydrogen
COPD	Chronic Obstructive Pulmonary Disease/Chronic Respiratory Disease
GEE	Google Earth Engine
GHG	Greenhouse gas
NOx	Nitric Oxide
OH	Hydroxyl
PCF	Permafrost Carbon Feedback
PPB	Parts per Billion
SWIR	Shortwave Infrared
VOC	Volatile Organic Compounds

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1. Introduction

Methane gas emissions have significant health impacts. The impacts are, in fact, so severe that if methane emissions are extensively reduced, the global climate could cool down by 0.3 degrees Celsius by 2040 according to the US Climate and Clean Air Coalition (CCAC, 2021), and could additionally prevent an estimated 180.000 deaths, 540.000 emergency room visits from asthma and 11.000 hospitalisations of elderly people globally each year (Ibid., 2021). On top of that, Indigenous communities generally face disproportionate health burdens due to toxic pollutions and environmental breakdowns. Especially, North American Indigenous communities face far bigger environmental health risks compared to the average North American population (Hoover, et al., 2012). In general, Indigenous communities are at higher risk of certain medical conditions such as asthma, heart disease, respiratory illnesses, etc. (EPA, 2022). Yet, climate change is not recognized as a form of violence, while we know the causes and effects. The impact of air pollution, like methane gas emissions, is a gradual process, meaning its deadly impact is not always visible. This phenomenon could be described as slow violence because it is incremental, spread across time and space, and often not seen as a form of violence (Williams, 2019). Greenhouse gases' pollution of the atmosphere bring severe consequences, such as climate degradation, crop failure, rise of sea levels and unpredictable weather patterns, etc. (Ibid., 2019). Heatwaves take the lives of the most vulnerable, and more powerful storms rip up landscapes. The destruction that climate change causes is often very violent. If climate change was recognised as violence, we would be able to understand that when we dig for coal, destroy the environment, pull out of international treaties, etc. we are committing a violent act (Ibid., 2019).

Nixon (2011) argues that environmental breakdown can occur slowly and invisibly, with a massive disconnect between cause and effect. But the final end result is still violence, against people and against nature. The destruction of the climate becomes an act of violence against the poor, people of colour and future generations (Nixon, 2011, pp. 6). Nixon coined the concept of ‘slow violence’ in 2011 as a way to describe how environmental disasters creep up on communities before exploding as disasters. Slow violence represents a way to not only speak of disasters that have short timescales, spectacular events or visible environmental impacts (Curry, 2017), but longer timescales that play out over generations, unspectacular events like asthma cases or specific plants that are slowly going extinct.

When building on the concept of slow violence and its implications for the environment and humanity, it is important to examine specific examples of anthropogenic activities that have the potential to exacerbate climate change and its impact. Methane is one of the anthropogenic greenhouse gases emitted from various sources such as livestock, oil-gas systems, landfills, coal mines, wastewater management and rice cultivation, but wetlands and permafrost are considered the major sources for methane emissions (Assareh, 2018). Arctic permafrost stores nearly 1.700 billion metric tons of frozen and thawing carbon including methane and carbon dioxide (Miner, 2022, pp. 55). Anthropogenic warming will set free an unknown amount of this carbon to the atmosphere, exacerbating the climate through heating, also known as permafrost carbon feedback (PCF) (Ibid., 2022). Abrupt thaw can emit substantial amounts of deeply sequestered carbon to the atmosphere rapidly. Carbon dioxide emissions are proportionally larger than methane gas emissions in the arctic, but methane gas is significantly more potent than carbon dioxide, with over 25 times the heat-trapping capacity in the atmosphere (US Environmental Protection Agency, 2022). Because of this, these emissions are supercharging global warming, climate change and human health globally. Ground-based surveillance and monitoring of methane emissions have been traditionally used but has shown to have limitations due to the geographic scale at which these hotspot emissions exist (Bermann, et al., 2023). Therefore, cost-effective aerial observation methods such as remote sensing satellite monitoring are thus highly needed to detect the increasing methane emissions. Methane has absorption lines in the infrared spectrum, which is distinct from other gas species, and can be utilized to detect and quantify methane emissions from other interfering components such as water, carbon dioxide and ethane (Ibid., 2023).

When reflected sunlight passes through emitted ground-level methane, the gas molecules absorb certain wavelengths in the infrared spectrum. The sunlight then reflects off the ground and can be detected through aerial observation. By performing what is called an infrared spectroscopic analysis of this reflected sunlight, excess methane from leaking permafrost and infrastructure can be found (Ibid., 2023). This way, detailed monitoring of methane gas emissions through satellite observations can provide a much better understanding of the Arctic's future role as a carbon source or trap, and the consequent impact on the earth's system and health, and the most vulnerable people who are exposed to its severe consequences (US Environmental Protection Agency, 2022). A new satellite, called Sentinel-5P, was launched in 2017 (Altaweel, 2022) which will provide higher sensitivity in measuring tropospheric methane and will enable more precise tracking of emissions across time. Data from the satellite will also monitor a narrow range within shortwave infrared (SWIR). This band is where methane is most detectable, which will allow more precise emission measurements to be made and from even smaller emission sources (Ibid., 2022). This will then allow a more comprehensive assessment on areas that may need to reduce their overall methane emissions. It is important to note, that to better limit methane emissions, more spatially sensitive satellites such as Sentinel-5p will be needed to monitor more sites and for longer periods of time (Ibid., 2022).

1.1 Aim

The aim of this study is to highlight the critical importance of understanding the environmental and human impacts which Arctic methane gas emissions bring about, namely 'slow violence'. This is carried out by analysing and comparing the effects which Arctic methane gas emissions have on the climate and indigenous communities in the Arctic by making use of remote sensing to gather data in the form of satellite images of methane hotspots in the Arctic. Making use of satellite images for these particular kinds of studies is notably important as it generates accurate and timely assessments of the gas emissions without forcing the researchers to enter inaccessible areas. The study will later discuss the impact these gas emissions can have on future generations and changes in health aspects which could potentially lead to slow violence over time and what has already led to slow violence today. Furthermore, this study aims to talk about the importance of using remote sensing in Human Rights studies. Studying the effects of events that lead to slow violence – with the use of remote sensing – can help utilise and understand the intensity and expansion of emitted gasses as well as the violent consequences it brings along (Miner, 2022). This study aims to contribute to a more comprehensive understanding of the complex interplay between environmental changes, human rights and long-term violence. The findings of this research will offer valuable insights into the urgent need for proactive measures to mitigate effects of permafrost methane gas emissions and safeguard the well-being of both present and future generations.

1.2 Research Questions

This study arrived at these research questions by exploring a wide variety of sources (Nixon, 2011, Curry, 2017, Shred-Hewitt, 2021, CCAC, 2021, WHO, 2015, Elder, et al., 2021, Walter Anthony, et al., 2018, Tollefson, 2018, Douglas, et al., 2020, Mendes, et al., 2022,) with the theme of slow violence on the Arctic Indigenous communities while investigating instances of methane gas emissions in the Arctic, the effects said emissions have on human health worldwide. The two research questions raised are as follows:

a. Do methane gas emissions have severe impacts on indigenous and human health in the Arctic?
b. How is remote monitoring of methane gas emissions in the Arctic helpful when preventing human rights violations?

These research questions are significant because – once uncovered – they will demonstrate that there is a significant connection between the concepts of slow violence, methane gas emissions and human rights. The purpose of this particular study is to shed light on the gaps in the literature and the present knowledge regarding the connection between the three concepts. There is currently a gap in the research and literature that fails to connect them (ECHO, 2023, IDNR, 2023, Bhatia, 2012, WHO, 2015, CCAC, 2019). While the link between slow violence and environmental degradation is increasingly acknowledged, the role of methane gas emissions in perpetuating slow violence has received inadequate attention. By acknowledging the existing gaps in the literature and emphasizing the potential connections and implications of methane emissions for slow violence, this study could contribute to bridging this knowledge gap and shed light on the broader socio-environmental consequences of methane emissions in the context of slow violence. By addressing these gaps, human rights studies can develop a more comprehensive framework that recognises and addresses the systemic and long-term nature of slow violence, incorporates environmental dimensions, engages marginalised communities and applies an intersectional analysis to better understand and address the impacts of slow violence on human rights.

1.3 Relevance to the study of Human Rights

This study seeks to make a valuable contribution to the field of Human Rights studies by addressing the long-term consequences faced by the global population when climate change and toxic pollution is being swept under the rug like a black swan by leaders, decision makers, organisational members, stakeholders etc. even when it has been widely predicted by experts for decades (Curry, 2017). This project uses remote sensing to monitor methane gas emissions in the Arctic. Using satellite imagery to quantify ground level methane emissions can be highly beneficial to support climate change mitigation, toxic pollution mitigation and human rights justification (Gorrono, 2022). By connecting remote sensing to slow violence, it can help unveil and perpetuate harm and injustice, and it can defy most conventional understanding of harm. The perpetrators and victims of slow violence may be human, but the way it plays out is environmental (Shred-Hewitt, 2021). This project seeks to highlight how marginalised, vulnerable, Indigenous communities are disproportionately affected by environmental degradation, resource depletion and socio-economic inequalities. By examining the slow violence inflicted on these communities, human rights studies can shed light on the underlying structures and power dynamics that perpetuate inequality and discrimination (Shred-Hewitt, 2021). By addressing the interconnections between slow violence, remote sensing and human rights, this research underscores the urgent need for equitable environmental policies, sustainable resource management and social justice initiatives. The findings of this study will contribute to the growing body of knowledge on the intersection of environmental harm, human rights and the responsibility of decision-makers to protect vulnerable communities. Ultimately, this research seeks to foster a more inclusive and rights-based approach to addressing the far-reaching consequences of slow violence on both human and environmental well-being.

1.4 Delimitations

The topics that this study will focus on are methane gas emissions, human rights and slow violence. These topics have been selected due to their interconnectedness and their significance in understanding the environmental impacts of pollution and their consequences on human health and security. This study limits itself to the impact of methane emissions and tropospheric ozone on the Arctic environment and therefore Indigenous communities living around the impacted environments. The Arctic regions under the microscope are Northern Canada, Greenland, Alaska, Lapland and Siberia. By doing so, the study seeks to contribute to the understanding of the collective challenges faced by communities across these different regions. The research methodology adopted for this study will use satellite images of Arctic permafrost methane hotspots, and will therefore have both qualitative and quantitative nature, enabling a comprehensive assessment of methane emissions and their impact on the environment. These delimitations were made due to the gap and lack in research on the environmental impacts of pollutions and slow violence. By setting these limits, it can provide insight into the connection between toxic pollutants' impact on the environment and the further connection this has on human security and slow violence amongst Arctic Indigenous communities. This also means that there have been slight setbacks during the research as theories, comparative research and previous materials are rare within environmental political science and other environmental social sciences.

2. Literature Review

This chapter is divided into two sections based on the research questions which seek to apply the concept of slow violence onto the increasing methane gas emissions in the Arctic. The first sub chapter explains the relevance of using remote sensing when monitoring methane gas emissions in the Arctic. Remote sensing is a great and enormously helpful tool when monitoring greenhouse gas emissions of any kind. It can monitor the rapid permafrost thawing and subsequent collapse of ground surfaces, also known as thermokarst (Elder, et al., 2021), which is threatening the stability of the underground carbon reservoir which will emit once the permafrost thaws. This phenomenon is poorly understood despite its potential impact on the global climate, economy and health of both humans and nature (Ibid., 2021). Therefore, remote sensing could be of great importance for this study.

The second sub chapter tests the impact which the emissions have on human health and the environment while connecting it to the method of monitoring methane gas emissions using remote sensing and/or satellite images. Methane gas is a key ingredient in the formation of tropospheric ozone, also known as ground-level ozone, and has severe consequences on the health of both humans as well as agriculture (CCAC, 2021). Long-term exposure to ozone leads to respiratory and cardiovascular issues, reduced lung function, airway inflammation, aggravated asthma, increased incidence of strokes etc. which leads to more hospitalisation admissions, school and work absences, medication use and even premature mortality (State of Global Air, 2019, ECHO, 2023). Furthermore, the chapter explains the phenomenon of developing countries with high ozone exposure suffering the most significant burden of ozone-related deaths and decreased quality of life (Bhatia, 2012).

2.1 Remote Monitoring of Methane Gas Emissions

To start off the literature review, a brief introduction is given on thermokarst and abrupt thaw. Thermokarst is the most widespread form of abrupt permafrost thaw and happens when soil warms up and melts the ice underground, causing land surface collapse. Land surface collapse results in the formation of distinctive landforms such as sinkholes, depressions and uneven or muddy terrain. Water pooling in collapsed areas leads to the formation of taliks (unfrozen thaw bubbles) beneath expanding lakes, accelerating permafrost thaw much faster and deeper than predicted from changes in air temperature alone (Walter Anthony, 2018, pp. 1). Abrupt thaw refers to the rapid and substantial melting of ice-rich permafrost, often triggered by various factors such as increased temperatures or changes in hydrology. It involves the sudden release of large amounts of previously frozen organic matter, including carbon dioxide and methane, into the atmosphere. Remote sensing and field observations reveal that localised abrupt thaw features, including thermokarst lakes, thermos-erosional gullies and peat-plateau collapse scars are extensive across Arctic landscapes with ice-rich permafrost (Ibid., 2018). Immense warming of the northern high latitudes is causing rapid permafrost thawing and collapse of ground surfaces (thermokarst), threatening the stability of the permafrost carbon (C) reservoirs (Elder, et al., 2021). The effect of widespread thermokarst and/or abrupt thaw on pan-Arctic greenhouse gas (GHG) emissions is poorly understood despite its potential impact on global climate. Here, remote sensing could be an excellent tool to help monitor GHG. Remote sensing technologies such as satellite observations and airborne measurements have been used to monitor methane emissions from permafrost. The use of these technologies has enabled researchers to map the spatial and temporal development patterns of methane emissions from permafrost regions (Elder, et al., 2021, Walter Anthony, et al., 2018, Tollefson, 2018, Douglas, et al., 2020, Mendes, et al., 2022).

Previous modelling research by Walter Anthony, et al. (2018) suggests that methane emissions from the formation of Arctic lakes could rise significantly as the planet warms during this century. The work, which assumes moderate global warming, hypothesises that a significant increase in the amount of methane bubbling up in Arctic lakes would nearly triple the total emissions from permafrost — to the equivalent of nearly 19 billion tonnes of carbon dioxide, or roughly half a year's worth of global CO2 emissions from industry (Tollefson, 2018). The study used Permafrost Carbon Feedback (PCF) modelling to focus on gradual thaw of near-surface permafrost that leads to enhanced carbon dioxide and methane emissions that accelerate global warming. Remote sensing was used to show that methane and carbon emissions from abrupt thaw beneath thermokarst (rapid permafrost thawing and subsequent collapse of ground surfaces) lakes will more than double radiative forcing from circumpolar permafrost emissions this century (Walter Anthony, 2018). The study demonstrates that abrupt thaw accelerates mobilisation of deeply frozen, ancient carbon, increasing ^{14}C-depleted permafrost soil carbon emissions by -125-190% compared to gradual thaw alone. Walter Anthony et al. (2018) determines that there is a need to incorporate abrupt thaw processes in remote sensing models and earth system models for more comprehensive projection of the PCF this century.

A study by Elder et al. (2021), conducted high-resolution airborne surveys of near-surface methane (CH_4) irregularities in permafrost ecosystems in Alaska and northwest Canada (Elder, et al., 2021, pp. 1). These measurements provided fine-scale resolution of the remote detection of CH_4 emission hotspots from natural Arctic environments. The study found that recent permafrost thaw converted soils with highly decomposable organic carbon into CH_4, and enhanced emission to the atmosphere (Ibid., 2021). The study estimates that thermokarst (rapid permafrost thawing and subsequent collapse of ground surfaces) CH_4 hotspots make up roughly 4% of the annual pan-Arctic wetland emissions. The study further estimates that Arctic CH_4 emissions may grow significantly in the future with anticipated increase in thermokarst across the permafrost landscape (Ibid., 2021). Methane emissions from abruptly thawing permafrost may constitute 50% of the total future radiative forcing from permafrost emissions, despite emissions being four times lower than carbon dioxide (Ibid., 2021). Elder et al. (2021) demonstrated the ability to detect unusual methane fluxes at high-resolution across large spatial domains, which is critical when informing ground-based study and for accurate spatial upscaling. The study presents a unique observation-based approach to estimate contemporary pan-Arctic terrestrial thermokarst methane emissions, which are expected to dramatically increase within the next century (Ibid., 2021).

A study which focused on abrupt permafrost thaw by Douglas, et al. (2020) found that increased rainfall leads to deeper thaw across all research sites in the Alaskan Interior with an increase of 0.7 cm plus minus 0.1 cm of thaw per cm of additional rainfall (Douglas, 2020). Additionally, disturbed wetland sites were the most vulnerable to rain-induced thaw with 1 cm of surface thaw per additional 1 cm of rainfall, meaning permafrost in tussock tundra, mixed forest and conifer forest was less sensitive to rain-induced thaw (Ibid., 2020). This study is a great example of why remotely sensed data of permafrost thaw and methane emissions is more important than doing on-the-ground data collection. Satellite images and remote sensing technologies allow for non-invasive monitoring and can provide valuable data while minimizing potential damage to the natural environment and preserves the integrity of the permafrost regions.

Another study that used remote sensing satellite image modelling is Mendes, et al. (2022) which focused on mapping potential toxic soil elements in agricultural soils. Soil contamination by potentially toxic elements is one of the greatest threats to environmental degradation. Potentially toxic elements accumulating in soil can mitigate their adverse effects on plants, animals and human health. Mendes, et al. (2022) evaluated the potential of using remote sensing images that reveal the bare soils, to detect and map potentially toxic elements in agricultural fields. Different remote sensing devices were used to give both spectral, temporal and spatial resolutions of the fields. The study demonstrated that using distinct satellite sensors to map potentially toxic elements in soil could help understand the spatial dynamics and environmental effects (Mendes, et al., 2022). It also demonstrated that the monitoring of potentially toxic elements could avoid further environmental degradation.

2.2 Methane Gas Emissions' Impacts on Human Health

Urban and rural living today involves several biological challenges, of which one is pollution, and therefore the impact of pollution on human biology such as mortality, morbidity, reproduction and development can be detected (Schell, et al., 2003, pp. 111). Most of the literature reviewed for this sub chapter put emphasis on the phenomenon of chronic exposure to low levels of air pollution having small impacts on individuals, but substantial effect on communities' health and wellbeing (Ibid., 2003). A study by the US Climate and Clean Air Coalition found that reducing methane emissions could avoid nearly 0.3 plus degrees Celsius of global warming by 2040 (CCAC, 2021). Methane emissions are increasing and because it is 80 times more powerful than carbon dioxide (UNEP, 2021) at warming the atmosphere, these emissions are supercharging further global warming and climate change. In fact, since pre-industrial times, methane has contributed to approximately 30 percent of global warming, and its spread is currently accelerating at an unprecedented rate not seen since the establishment of record-keeping in the 1980s (Ibid., 2021). Although methane emissions and climate change are already understood as an environmental problem, and increasingly as an economic one, the social and human rights implications of climate change are given little discussion. Global warming threatens food security, public health, properties and the livelihoods and lives of the affected communities (Aminzadeh, 2007, pp. 231). Like other environmental issues, global warming and methane emissions threatens the human rights of those living in the affected communities.

The health and well-being of Arctic Indigenous communities are utterly dependent on what they are able to harvest from the land and the sea around them (Lynge, 2009), and because of this, anything that threatens their subsistence activities threatens their health. The melting permafrost will make it more difficult to freeze their food the traditional ways, and the shifting grounds are damaging their sanitation and water supply systems as well as housing (Ibid., 2009). All of these issues affect Inuit health and well-being, either physically due to the way they threaten the safety of their food and water, or socially and mentally because they threaten the way of life which their identity is based upon.

According to a study published by Coggins et al., Arctic regions are experiencing transformative climate change impact as it is warming considerably faster than the rest of the world and will witness the most climate change globally this century (Coggins, et al. 2021). Approximately ten percent of the Arctic's four million inhabitants who identify as Indigenous experience disproportionate risks to these impacts, as they generally live in remote regions and maintain strong links to the environment through subsistence-oriented hunting, herding, foraging and fishing. The study by Coggins et al. sheds light on the critical considerations of climate justice in relation to Arctic Indigenous Peoples. By adopting a rights-based approach to justice, the authors emphasize the importance of safeguarding the rights of Indigenous communities not to be adversely affected by the impacts of climate change. These rights encompass a range of aspects, including the right to historically owned lands and resources, the right to maintain cultural traditions, the right to self-determination among others. All of which are rooted in the fundamental right to a thriving and sustainable environment (Ibid., 2021). By exploring these dimensions of climatic justice, the study by Coggins et al. aims to contribute to the protection and promotion of the rights of Arctic Indigenous Peoples in the face of ongoing climate change.

One impact of methane emissions that tends to receive less attention, is that it is the primary ingredient in the formation of another greenhouse gas, namely ozone. When accumulated in the lower atmosphere, it is called ground-level ozone. Ozone is a key element of smog and is toxic to humans and plants (CCAC, 2021). Harmful air pollutants like methane and ground-level ozone can harm native plants, including medicinal plants, crops and trees. Ground-level ozone is responsible for up to 90% of air pollution injury to plants (MCAF, 2023). Ozone hinders plant growth and plant development and causes decreases in crop yield. Many indigenous communities rely on plants that are infected by toxic pollutants. Vital global crops, including cotton, peanuts, soybean, wheat and corn have all been proven to be negatively impacted by ozone. Similarly, the IDNR (2023) found that ground-level ozone damages vegetation and ecosystems by inhibiting the ability of plants to open the microscopic pores on their leaves to breathe. It interferes with the photosynthesis process by reducing the carbon dioxide which the plants need to process in order to release oxygen (IDNR, 2023). Increased levels of ozone can cause a decrease in agricultural crop, reduced growth and survivability of tree seedlings as well as increased vulnerability to diseases, pests, harsh weather etc. (Ibid., 2023).

Additionally, a report by The State of Global Air found that breathing ozone damages human lung tissues. Long-term exposure to ground-level ozone contributed to an estimated 365.000 breathing-related deaths in 2019. That equates to 11% of all Chronic Obstructive Pulmonary Diseases (COPD) deaths globally (State of Global Air, 2019). Over 70% of these deaths occurred in India with 168.000 deaths and China with 93.300 deaths as a result of their higher ozone exposure, large populations and higher age-standardised COPD death rates caused by ozone (Ibid., 2019). By comparison, according to the Global Burden of Disease, the number of ozone-caused deaths in High Income Super Region countries accounted for less than 9% of the global total (Ibid., 2019). Older adults and countries with aging populations suffer the highest burden of COPD. The growth and aging of populations accounts for much of the increase in COPD-related deaths in countries across Asia. Because of these countries' large populations, these trends, in turn, significantly influence the overall global increase in the number of ozone-caused deaths from COPD (State of Global Air, 2019). The US Climate and Clean Air Coalition (2021) explains that the number of deaths does not fully cover its possible damage. The number of people who do not die but suffer lower quality of life or multiply national healthcare spending is likely much higher (CCAC, 2021). Because tropospheric ozone damages lungs, people with asthma and COPD may suffer reduced lung capacity and intensified disease severity. This is particularly concerning for the many respiratory disease sufferers living in developing countries where life-saving medicine is much less accessible (Ibid., 2021). For these groups, a future with continually increasing gas emissions could have life or death implications.

A study carried out by the Iowa Department of Natural Resources (IDNR) (2023) found that breathing ground-level ozone can trigger chest pain, coughing, throat irritation and congestion as well as worsen bronchitis, emphysema and asthma (IDNR, 2023). Repeated exposure may permanently scar lung tissue. The European Climate and Health Observatory (ECHO) (2023) expects that a higher probability of heatwaves will likely lead to increases in ground-level ozone concentration peaks. Increased solar radiation and summertime temperatures will also accelerate the chemical process of ozone formation (ECHO, 2023), as tropospheric ozone is not emitted directly into the air but is made through a photochemical reaction which involves methane, nitrogen oxides and volatile organic compounds mixed with sun light and high temperatures (EPA, 2023). Meaning, if there is more of one thing, it triples the amount of the next in the cycle. Ozone concentrations are typically higher in the summer months when there is plenty of solar radiation to stimulate the reactions, but can also increase in colder months (Ibid., 2023). Future climate change is expected to increase ground-level ozone concentrations, and therefore the mortality related to acute ground-level ozone exposure is expected to increase by 2050 (Ibid., 2023), and will lead to an estimated 15% increase in the total number of ground-level ozone-related acute premature deaths in Europe by 2080 (Ibid., 2023). Schell, et al., (2003) demonstrates that exposure to specific air pollutants such as ground-level ozone has been associated with increased cause-specific mortality rates, and chronic, low-level exposure to air pollution shortens life expectancy by one to two years, a substantial effect compared to other environmental risk factors (Schell, et al., 2003, pp. 113). Although air pollution can have health effects throughout the body, the target organ for many victims is the respiratory system, and effects thereof include acute and chronic changes in pulmonary function, increased incidence and prevalence of respiratory symptoms, sensitization of airways to allergens and exacerbation of respiratory infections such as rhinitis, sinusitis, pneumonia, alveolitis and legionnaires' disease (Ibid., 2003, pp. 114).

Toxicological and epidemiological studies carried out by the World Health Organization (WHO) (2015) reports an effect of short-term exposure on heart rate variability, systemic inflammation and oxidative stress as well as fairly consistent associations with cardiovascular mortality (WHO, 2015), and recent reviews have noted credible evidence for a causal relationship between long-term exposure to ground-level ozone with cardiovascular, reproductive/developmental and central nervous system effects as well as total mortality (Ibid., 2015). There is no apparent threshold concentration below which health effects do not occur.

The study by WHO (2015) further establishes that ground-level ozone is present worldwide, as wind can move ozone over large distances, called "transboundary ozone" (Ibid., 2015). Ground-level ozone concentrations are often higher in suburban and rural areas compared to urban cores, partly because freshly emitted vehicle exhaust destroys ozone nearby but helps pushing it downwind (Ibid., 2015). Another concern about ground-level ozone is that it is deteriorating labour productivity in agricultural and other outdoor sectors and workers exposed to ozone and suffering from its negative health impacts. One such study found that even exposure to ground-level ozone had an impact on productivity, making further impacts on economy as well as health (Bhatia et al., 2012). WHO (2015) established that children are considered particularly vulnerable to ground-level ozone-related health impacts, as they spend more time outdoors doing more physical activity which causes faster and deeper breathing, and children have higher metabolic rates compared to the general population (WHO, 2015). Child growth and development is a measure of health that is sensitive to subtle changes in the environment, and alterations in community child growth patterns can signal the presence of a stressor before morbidity or mortality occurs (Schell, et al., 2003, pp. 114). Schell, et al., (2003) explains a research method in which an ecological approach compares child growth in two or more locations that differ in the severity of air pollution. These methods have typically reported reduced weight, height and skeletal maturation among children in areas with higher pollution levels (Ibid., 2003). Schell et al., (2003) also found that air pollution may affect the foetus. The relationship between prenatal growth and air pollution have been found with negative associations. All in all, the pervasiveness of air pollution means that large numbers of people are adversely affected even if the effect on one single individual is slight. On a community basis, air pollution contributes significantly to increased mortality, morbidity and growth deficits. These effects are present at levels common in many urban and suburban communities (Ibid., 2003, pp. 116). Other populations at increased risk include people with pre-existing respiratory disease, older adults, people with certain genetic polymorphisms and people with reduced intake of certain nutrients (WHO, 2015).

While the focus here has been on the health consequences of ground-level ozone pollution in various contexts, it is essential to consider its potential ramifications for Arctic Indigenous communities as well. The exposure to ground-level ozone has been associated with a range of health effects, of which the detrimental effects extend to agricultural productivity and ecosystem health, resulting in reduced crop yields and increased susceptibility to diseases and pests (Bhatia et al., 2021, IDNR, 2023). These can likewise have detrimental effects on Arctic Indigenous communities. By recognising the broader implications of ground-level ozone and methane pollution, including its effects on the health of Arctic Indigenous communities, it becomes evident that addressing this issue is vital not only for human health but also for the preservation of ecosystems and sustainable livelihoods. The interconnectedness between the impacts of ground-level ozone pollution on different populations underscores the importance of comprehensive strategies and policies to mitigate its effects on both human and environmental well-being. There are many different Indigenous populations around the world, and many of these groups are more vulnerable to the human health impacts of climate change than the general population because they have an increased susceptibility of certain medical conditions such as asthma, heart disease, diabetes, obesity, dementia and many more. These chronic medical conditions put individuals at even more risk for illness and injury as the climate changes (EPA, 2022), and could even have occurred due to the changing climate. Indigenous populations have a special connection to the natural environment, and a changing climate is threatening natural resources and ecosystems that are essential to their livelihoods, food sources, cultural practices, etc.

2.3 Gaps in the Literature

The various literature used for this study focus on the impacts of methane emissions on suburban human health, recognizing the potential risks and implications of increased methane levels in the atmosphere (ECHO, 2023, IDNR, 2023, Bhatia, 2012, WHO, 2015, CCAC, 2019). However, these studies fail to directly link the impacts to the Indigenous communities living close to the source, as well as link the impacts to the concept of slow violence coined by Nixon (2011). One explanation could be that the concept of slow violence is a relatively recent framework that has yet to gain foundation and attention in the field of environmental and scientific studies. Furthermore, the complex nature of slow violence and its multi-faceted manifestations might make it challenging to establish a direct causal link between methane emissions and slow violence. Slow violence encompasses a range of socio-environmental factors and processes that unfold over extended periods, involving a web of interconnected causes and effects (Nixon, 2011). These complexities can make it difficult to attribute specific instances of slow violence solely to methane emissions. However, despite the lack of explicit connection in current studies, it is crucial to recognise the potential indirect links between methane emissions, slow violence, and its impact on Indigenous human health and nature. The gradual and cumulative effects of climate change, including increased methane emissions, can contribute to the erosion of

Indigenous communities' well-being (ECHO, 2023, WHO, 2015), disrupt ecosystems (Bhatia et al., 2012, IDNR, 2023), exacerbate environmental inequalities and perpetuate social injustices (CCAC, 2021) over time. These indirect impacts align with the underlying principles of slow violence, even if they are not explicitly labelled as such in the literature.

Another gap in existing literature, is that it overlooks the consequences of methane emissions' social and cultural impacts within the Arctic regions. Slow violence, in the face of methane emissions could have cumulative social and chronic impacts on local, Indigenous communities and vulnerable ecosystems (UN DESAIP, 2023). To reiterate, disproportionate pollutant exposure by socioeconomically disadvantaged groups exacerbates risk of poor health and wellbeing (Schell, et al., 2003, pp. 111). Indigenous peoples are amongst the first people to face the direct and harmful consequences of climate change, due to their dependence on, and close relationship with, the environment and its resources (Ibid., 2023). Climate change multiplies the difficulties which indigenous communities are already facing, including political and economic marginalisation, loss of traditional land and resources, human rights violations, discrimination and unemployment – all examples of slow violence (Ibid., 2023). Studying the policy and governance responses to slow violence caused by methane gas emissions in the Arctic could be an essential aspect of addressing this gap. This could involve examining the effectiveness and adequacy of existing mitigation measures, regulations and international agreements on mitigating slow violence and ensuring social and environmental justice for affected communities (Nixon, 2011) like indigenous peoples in the Arctic.

By acknowledging the existing gaps in the literature and emphasizing the potential connections and implications of methane emissions for slow violence, this study could contribute to bridging this knowledge gap and shed light on the broader socio-environmental consequences of methane emissions in the context of slow violence.

3. Theoretical Foundation

This chapter represents the theoretical framework of the thesis, namely, slow violence and its magnitude when understanding the evolvement of toxic emissions and its violent consequences on communities and populations. This framework goes in depth with Nixon's definition of the concept, a counter argument by Thom Davies (2019) as well as the importance and significance of this research. A definition on slow violence is given for clarification and compared with Galtung's (1990) concept of structural violence. Lastly, this chapter goes in depth with explanations of what is missing in human rights studies as well as a description of the connection between the terms discussed. To explain this, Shred-Hewitt's (2021) arguments are illuminated. He argues that slow violence gives us the ability to recognise structural violence and helps us unveil the structural and systemic factors that perpetuate harm and injustice. Understanding slow violence is important because it defies most conventional understanding of harm (Shred-Hewitt, 2021). Slow violence highlights how marginalised communities and vulnerable populations are disproportionately affected by environmental degradation, resource depletion and socio-economic inequalities. Moreover, the concept of slow violence challenges the traditional conceptions of violence by highlighting the interconnectedness between ecological degradation, social injustice and human rights violations. It recognises that harm inflicted on the environment has far-reaching consequences that extend beyond immediate and visible acts of violence (Nixon, 2011). By examining the slow violence associated with methane emissions, this study aims to unravel the complex web of systemic factors and power dynamics that perpetuate environmental degradation and its disproportionate impact on marginalised communities and vulnerable populations (Shred-Hewitt, 2021). Furthermore, this study recognises the potential of remote sensing technology to contribute to the understanding of slow violence and its impacts. Remote sensing provides an invaluable tool for monitoring and quantifying methane gas emissions, allowing for objective and data-driven analysis of the extent and distribution of environmental harm (Altaweel, 2022, Gorrono, 2022, Avtar, et al., 2021). By integrating remote sensing data with human rights studies, a more nuanced understanding of the spatial and temporal dynamics of slow violence can be achieved. In short, this chapter provides an overview of the theoretical framework that underpins this thesis, focusing on the concept of slow violence and its significance in understanding the evolvement of toxic emissions and their violent consequences on communities and populations.

The objective of this study is to investigate the relationship between methane emissions and slow violence in the context of human rights studies, to examine the impacts of slow violence on marginalised communities and vulnerable populations that are most affected by the consequences of methane emissions. As mentioned earlier, detailed monitoring of methane gas emissions through satellite observations can provide a better understanding of the Arctic's future role as a carbon source or trap, and the subsequent impact on the earth's system and health, and the most vulnerable people who are exposed to its severe consequences (US Environmental Protection Agency, 2022). Anthropogenic warming will set free an unknown amount of this carbon to the atmosphere, exacerbating the climate through heating (Miner, 2022, pp. 55). Abrupt thaw can emit substantial amounts of deeply sequestered methane to the atmosphere rapidly.

To start off the theoretical foundation, a brief introduction is given on slow violence. As mentioned earlier, Nixon (2011) coined the concept of slow violence in 2011 as a tactic to address our inattention to calamities which are slow and long lasting. Calamities that patiently distribute their devastation while remaining outside of our flickering attention spans – and outside the purview of a spectacle-driven corporate media (Nixon, 2011). The intensification of climate change – for example resulting from increased methane emissions from permafrost – may lead to slow violence in a way that environmental disasters creep up on communities before exploding as calamities (Curry, 2017). Curry (2017) argues for slow violence as also being a 'predictable surprise' which has several characteristics: A predictable surprise is where leaders knew all along that a problem existed and that it would not solve itself; Organisational members, stakeholders etc. recognise that a problem is getting worse over time, but fixing the problem would acquire significant costs in the present, while the benefit of action would be delayed or go unnoticed; A small minority benefits from inaction and is motivated to overthrow the actions of leaders for their own private benefit (Ibid., 2017). Slow violence is always different from, and more insidious than, structural violence. But as structures of political neglect, they have similarities. In particular, there is a political willingness to ignore a series of reports. This is what Curry (2017) calls a 'Black Elephant'. A 'Black Elephant' is a term coined to describe a phenomenon that combines elements of a black swan event with an elephant in the room. This concept refers to an event that is highly probable and anticipated by experts, yet often disregarded or downplayed until it actually occurs (Ibid., 2017).

The concept of slow violence is important to connect to the topic of the ongoing, rapidly emitted methane gas emissions in the Arctic as these emissions have significant health impacts. As previously explained, the impacts are so severe that if methane emissions are extensively reduced, the global climate could cool down by 0.3 degrees Celsius by 2040 according to the US Climate and Clean Air Coalition (CCAC, 2021), and could additionally prevent an estimated 180.000 deaths, 540.000 emergency room visits from asthma and 11.000 hospitalisations of elderly people globally each year (Ibid., 2021). These long-term consequences which methane emissions have on both the environment and human health contribute to long-term and intergenerational harm. The degrading climate that will exacerbate due to methane emissions can have long-lasting impacts on communities and future generations (Ibid., 2021). By examining the slow violence associated with methane emissions, this study can highlight the persistent and cumulative nature of this harm over time. It enables a comprehensive understanding of the consequences of methane emissions, facilitates the pursuit of environmental justice, and explains long-term impacts of climate change on communities and human rights.

The concept of slow violence overlaps with Johan Galtung's (1990) concerns about structural violence. Structural violence, for Galtung, stands in opposition of what counts as violence per se. Galtung sought to highlight the enormous structures that can give rise to personal violence and construct forms of violence in and of themselves (Galtung, 1990, Nixon, 2011). Such structural violence may range from the unequal morbidity that results from a commodified health care system to racism itself. What slow violence shares with structural violence is a concern with social justice, hidden agency and certain forms of violence that are invisible (Nixon, 2011). Structural violence is a theory that entails rethinking different notions of causation and agency with respect to violent effects. Slow violence, by contrast, might well include forms of structural violence, but has a wider descriptive range in calling attention, not simply to questions of agency, but to broader, more complex descriptive categories of violence enacted slowly over time (Ibid., 2011).

Similarly, Nixon (2011) explores the concept of ‘the environmentalism of the poor’ which involves social movements and struggles arising from environmental conflicts when impoverished people struggle against powerful states or private interests that threaten their livelihood, health, culture, etc. (Ibid., 2011). In the global resource wars, the environmentalism of the poor is frequently triggered when an official landscape is forcibly imposed on a vernacular one, meaning when metropolises disturb local, domestic landscapes. These are social conflicts that appear when the ecological impacts of an economic activity are unevenly and unjustly distributed amongst society. Usually, the ecological impacts are disregarded and not taken care of by businesses and affect much more those who have less resources to fight them (Ibid., 2011). Nixon (2011) argues then that “the exponential upsurge in indigenous resource rebellions across the globe during the high age of neoliberalism has resulted largely from a clash of temporal perspectives between the short-termers who arrive (with their official landscape maps) to extract, despoil and depart, and the long-termers who must live inside the ecological aftermath and must therefore weigh wealth differently in time scales” (Ibid., 2011, pp. 17).

Similar to the concept of the environmentalism of the poor, Schell (2003) describes the biocultural approach of anthropologists as being well suited to understand the interrelationship between urbanism and human biology. Urbanism is a social construction that has continuously changed and presented novel adaptive challenges to its residents (Schell, 2003, pp. 111). Urban living today involves several biological challenges such as air pollution, lead and noise. The impact of pollution on human biology such as mortality, morbidity, reproduction and development, as explained earlier, can be seen. Chronic exposure to low levels of these pollutants has a small impact on the individual, but a substantial amount of people is exposed to pollution that the effect is significant (Ibid., 2003).

Thom Davies (2019) counter argues for Nixon's definition on slow violence. He explores the gradual brutalities that communities surrounded by petrochemical infrastructure endure over time and argues that structural inequality can mutate into harmful instances of slow violence (Davies, 2019, pp. 409). He further argues against Nixon's framing of toxic landscapes as entirely invisible to the people they impact. Instead of accepting "out of sight", we have to ask, "out of sight to whom?". Toxic environments are not always sensuous spaces that give up their clues and dangers. Indeed, chemicals that avoid human perception can often prove the deadliest, but toxic geographies are also lived environments, where people encounter hazards in their day-to-day lives, in mundane and incremental ways (Ibid., 2019) and not always entirely out of sight as Nixon puts it.

According to Shred-Hewitt (2021), slow violence refers to the gradual and long-lasting harm caused by environmental conditions, which may not be immediately apparent and are often only recognised in hindsight. These forms of harm are inflicted on affected individuals over time, and the perpetrators may not be physically present or identifiable, making the harm difficult to define and attribute (Shred-Hewitt, 2021). Slow violence is often not recognised as violence at all, and, if legally recognised, the act is not recognised as an assault on the health of its victims, and neither do those that suffer often not even perceive it as such, as it has the slow effect on the victims (Ibid., 2021). Even if the perpetrators come to justice, it will be for their careless industrial practices, not for the carcinogens they put into living bodies. For the victim of slow violence, there is no punctual moment of violence, there is no discernible beginning to their suffering and there is no end to hope for. The harm is environmental, and their home becomes a weapon used against them (Ibid., 2021). Nixon (2011) points out that slow violence is a threat multiplier that can fuel long-term, proliferating conflicts in situations where conditions for sustaining life become increasingly but gradually degraded (Shred-Hewitt, 2021, Nixon, 2011).

Methane contributes to warming the planet, and for most parts of the Global North and capitalist states, the consequences of our warming planet are still in the early stages. In the Global South, the climate change-linked environmental destruction has been impacting lives and livelihoods for decades. The irony of this is that the countries and communities contributing the least to the destruction of the planet are feeling the worst consequences and have felt them for much longer than the ones contributing the most (Barnwell, Heleta, 2021). The crises around the world are a result of relentless exploitation of natural resources by the capitalist states and multinational corporations over the past few centuries. Overall, the capitalist states have historically been responsible for 92% of the world's excess carbon emissions. Meanwhile, countries and communities contributing the least to these emissions are warming and depleting at record levels (Ibid., 2021). For instance, children growing up in the MENA region are exposed to more heatwaves, droughts and crop failures than anywhere else in the world. Youth born in the region in 2020 are over seven times more likely to be exposed to extreme heatwaves over their lifespan compared to adults born in the 1960s (Ibid., 2021). Climate change-linked natural disasters are expected to amplify and worsen inequality and poverty in fragile societies. The result of this will be a vicious cycle, locking affected societies in a trap of violence, vulnerability and climate change impacts (Ibid., 2021).

Consequently, it is evident that the warming of the climate has disproportionately burdened vulnerable countries and communities and exacerbated climate injustice. This cycle of violence, vulnerability and environmental degradation threatens to perpetuate a destructive and unjust trajectory for affected communities. In the Arctic, the thawing permafrost turns the earth to mud or even lakes, leading to entire villages to relocate in Alaska, Nunavut and Siberia (Schreiber, 2018, The Canadian Climate Institute, 2022). The ground is changing, and buildings and roads that are built upon the thawing permafrost are moving and cracking. Homes and housing in the nearest towns like Iqaluit are unjustly expensive and can be compared to New York City prices. But there still are not enough housing for everyone relocating to these villages (Ibid., 2018). The homeless shelters are overcrowding in Iqaluit, and at the same time, precipitation patterns are changing to more unreliable snowfall in the Arctic, affecting the land even more. It is difficult to build new houses on thawing permafrost and cost inefficient to ship building materials into the Arctic (Ibid., 2018). The main problem, though, is soil moisture. When water freezes, it expands, resulting in the ground rising, when it thaws, the soil contracts and the ground sinks. In many Arctic regions, the permafrost has entered a cycle of thawing and refreezing each season, compared to its previous state of stability. This cyclic process causes the ground to rise and sink along with the changes in weather conditions. The impact of thawing permafrost is particularly severe in Russia, where some of the largest Arctic cities are experiencing drastic transformations. In the coal-mining town of Vorkuta, about 40% of the buildings have become distorted due to ground shifts. Similarly, in Norilsk, the largest city built on permafrost, the thaw has damaged around 60% of structures, leading to a significant number of abandoned houses and resulting in substantial relocation flows from Siberia (Ibid., 2018). Meanwhile, Greenland has witnessed the emergence of wildfires in regions that were previously covered by icy tundra. These fires now pose a serious threat to nearby towns and villages. In Alaska, numerous towns are encountering challenges in finding suitable burial grounds, as former cemeteries have transformed into waterlogged swamps. Moreover, some towns are experiencing a complete scarcity of solid ground. As a response to these pressing concerns, the Alaskan village of Newtok recently secured funding to initiate the relocation of the entire community to a safer location (Ibid., 2018).

So, where does the role of remote sensing fit in? There are numerous advantages and limitations of using remote sensing in this context and has great potential for uncovering slow violence and human rights dynamics. Remote sensing technology has experienced impressive popularity over the last two decades, becoming a fundamental part of research today. Space-based satellite technologies facilitate access to inaccessible terrains, help humanitarian teams, support complex emergencies and contribute to monitoring and verifying conflict zones (Avtar, et al., 2021). As an example, Avtar et al. (2021) investigated the effectiveness of using remote sensing to complement international peace and security activities with its ability to provide objective near real-time insights at the ground level (Ibid., 2021). Another study used nighttime-light data to quantify economic inequality (Usman, et al., 2020, pp. 1). This study explained how households tend to segregate into richer and poorer neighbourhoods, and the correlation between light emission and economic thriving suggests that spatial variance of remotely sensed light per person might carry a signal of economic inequality. The study found a significant relationship between the resulting light-based inequality indicator and existing estimates of net income inequality (Ibid., 2020).

Monitoring of methane gas emissions call for an entirely different method, where a Tropospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor has been demonstrated to be effective in detecting ground-level methane emissions (Altaweel, 2022). The instrument uses ultraviolet and visible, near-infrared and shortwave infrared spectral bands from the TROPOMI passive spectrometer, and has spatial resolution of about 50 square kilometres (Ibid., 2022). Using satellite imagery to quantify ground level methane emissions is highly beneficial to support climate change mitigation and human rights justification (Gorrono, 2022). This kind of visual interpretation comes with its disadvantages in that it may require extensive training and is labour intensive. Additionally, objects may be misinterpreted, and distortions may occur in an image due to the relative motion of sensor and source (Lillesand, 2015, pp. 31).

3.1 What is Missing in Human Rights Studies?

Human rights studies often focus on more immediate and direct forms of violence, neglecting the recognition and understanding of slow violence. Today, several conventions have been published aiming to eliminate all forms of discrimination against women, persons with disabilities, preserving the rights of persons of race, indigenous peoples, children and nature, etc. With slow violence, it allows us to shed light and attention on the temporal dimension of harm and insecurity on inter-generational justice that unfold over time within the sphere of human rights studies, emphasizing the enduring consequences of environmental degradation, social injustice and resource depletion (UNESCO, 1997).

As mentioned earlier, this study seeks to recognise slow violence and to fill in the research gap between slow violence and methane gas emissions since the published texts and journals fail to emphasise the violent effects which toxic emissions have on the general public and its health. It is essential to establish a connection between this fact and the concept of slow violence, which involves environmental conditions that actively harm the affected individuals. However, this harm unfolds gradually, lacks clear definition and is often only recognised in hindsight, after its perpetrators are long gone (Shred-Hewitt, 2021). One factor, which is of considerable interest to human rights research, and important for our understanding to reiterate, is that slow violence is often not recognised as violence at all, and, if legally recognised, the act is not seen as a violation on the health of its victims, and the victims do often not perceive it as such, as it has the slow effect on the victims (Ibid., 2021). Even if the perpetrators come to justice, it will be for their destructing industrial practices. By addressing these gaps, human rights studies can develop a more comprehensive framework that recognises and addresses the systemic and long-term nature of slow violence, incorporates environmental dimensions, engages marginalised communities and applies an intersectional analysis to better understand and address the impacts of slow violence on human rights.

3.2 How is Slow Violence Important to Human Rights Studies? Connecting the Concepts

Slow violence gives us the ability to recognise structural violence and helps unveil the structural and systemic factors that perpetuate harm and injustice. Understanding slow violence is important because it defies most conventional understanding of harm (Shred-Hewitt, 2021). Slow violence highlights how marginalised communities and vulnerable populations are disproportionately affected by environmental degradation, resource depletion and socio-economic inequalities. While victims and perpetrators may be human, the way it is carried out is environmental, it does not fit into news cycles, election seasons or economic quarters. Nixon (2011) often speaks about the 'out of sight' character of slow violence, but as Davies (2019) points out, toxic environments are not always sensuous spaces that give up their clues and dangers (Davies, 2019, pp. 409), and 'out of sight' is a relative term as those afflicted by slow violence are rarely mentioned (Shred-Hewitt, 2021). What categorises it as 'out of sight' is its lack of political recognition in the ordinary media (Ibid., 2021). News cycles come in waves, but the poisons, cancers and broken socio-ecological systems stay, as do the communities that bear them witness. By examining the slow violence inflicted on these communities, human rights studies can shed light on the underlying structures and power dynamics that perpetuate inequality and discrimination.

The concept of slow violence highlights the intrinsic link between human rights and environmental issues, especially in the context of the Anthropocene. In this era, global challenges such as climate change, biodiversity loss and pollution may appear abstract, allowing major perpetrators to evade accountability for the harm they cause (Ibid., 2021). Slow violence recognises that environmental degradation, climate change and resource exploitation have significant human rights implications. The slow violence resulting from air and water pollution, deforestation and/or climate change can lead to adverse health effects, displacement, loss of livelihoods, and cultural erosion, all of which have human rights dimensions. If we are to strive for a more just ecological future, then recognising what is to be overcome is one of the first challenges (Ibid., 2021). Integrating slow violence into human rights studies allows for a more comprehensive understanding of these interdependencies.

Slow violence additionally draws attention to the temporal dimension of harm, focusing on the long-lasting and intergenerational impacts of environmental degradation and social injustice (Nixon, 2011). By considering the long-term consequences of slow violence, human rights studies can address issues of intergenerational justice, recognising the rights of future generations to a healthy environment, sustainable resources and social well-being.

The significance of this particular study is that its purpose is to shed light on the gaps in the literature and the present knowledge regarding the connection between methane emissions, slow violence and human rights. There is currently a gap in the research and literature that fails to connect these three concepts (ECHO, 2023, IDNR, 2023, Bhatia, 2012, WHO, 2015, CCAC, 2019). By acknowledging the existing gaps in the literature and emphasizing the potential connections and implications of methane emissions for slow violence, this study could contribute to bridging this knowledge gap and shed light on the broader socio-environmental consequences of methane emissions in the context of slow violence.

4. Methodology

Anthropogenic warming threatens to set an unknown quantity of the nearly 1.700 billion metric tonnes of frozen carbon free from Arctic permafrost to the atmosphere, impacting the climate through heating, also known as permafrost carbon feedback (PCF) (Miner, 2022, pp. 55). Abrupt thaw can emit substantial amounts of deeply sequestered carbon to the atmosphere rapidly (US Environmental Protection Agency, 2022). Detailed monitoring of methane gas emissions through satellite observations can provide a much better understanding of the Arctic's future role as a carbon source or trap, and the subsequent impact on the earth's system and health, and the most vulnerable people who are exposed to its severe consequences. This chapter represents the methodology of the thesis, where the following research objectives will be addressed. First, it will describe how the theoretical framework – as introduced above – will be applied. This objective aims to understand the potential release of frozen methane from Arctic permafrost and its influence on climate through heating. Second, it will describe the research design which consists of a remotely sensed sampling method to monitor methane emissions in the Arctic. This objective aims to establish a systematic approach for collecting satellite observations of methane emissions and analysing their spatial and temporal patterns. Third, a description of the data collection is given, including the acquisition of satellite imagery and the retrieval of methane emissions. Fourth, a discussion on reliability, validity and the ethical considerations associated with conducting remotely sensed research in the Arctic is given. These research objectives are designed to guide the implementation of the research methodology and contribute to a comprehensive understanding of methane emissions in the Arctic, their impact on Inuit communities as well as the Earth's system and health, and the ethical implications of conducting remotely sensed research in this context.

As mentioned earlier, slow violence is the human health impacts of environmental degradation and is carried out in various ways. The intensification of climate change may lead to slow violence in a way that environmental disasters creep up on communities before erupting as disasters (Nixon, 2011). The concept of slow violence is important to connect to the topic of the ongoing, rapidly emitted methane emissions in the Arctic as these emissions have significant health impacts (Curry, 2017). The consequences as described in the theoretical foundation as well as the literature review, are of major concern and interest in the study of human rights and in previous slow violence research and connects directly to research question (a). Furthermore, there are times when the methods of remote sensing can grant a better and more useful understanding of the damages and consequences of methane emissions, for example by making a spectroscopic analysis as opposed to an expensive, in-person field trip which would otherwise have taken place (Bermann, 2023). Bermann (2023) carried out a study of spectroscopy which showed an efficient technology for methane detection and proved that infrared satellite imagery can distinguish methane from other components such as water, carbon dioxide, ethane etc. This phenomenon has paved the way for this study as well as research question (b) which seeks to identify if it is possible to monitor methane gas emissions in the Arctic remotely.

4.1Research design

Remote sensing is a non-contact sampling method of data collection and recording of information which involves sampling and quantisation of reflectance from the sampling ground area using ultraviolet, visible, infrared and microwave regions of electromagnetic spectrum by satellites (Bhatta, 2013, pp. 1). Comparing observational information with theoretical ideas can constitute the core of scientific inquiry and represents the process by which scientific knowledge is generated (Bhatta, 2013, pp. 83). Research in remote sensing can interestingly be viewed as the interaction between theory and observation. Theory consists of ‘ideas’ about how the earth’s surface features are structured, and how they interact with one another. Observation consists of ‘evidence’ about the earth’s surface features (Ibid., 2013). Remote sensing is the science, technology and art of obtaining information about an object, area or phenomenon by analysing data acquired by a device that is not in physical direct contact with the object, area or phenomenon under investigation (Ibid., 2013).

Environmental Monitoring describes the process of finding and analysing satellite images of chosen areas to observe and monitor the environment (Lillesand, et al., 2015). It is likewise a tool to support policy development and its implementation as well as develop information for reporting to national policymakers, international forums and the public (UNECE, 2003).

One form of remotely sensed data collection is the ground-based measurements of the reflectance and/or emittance of surface materials to determine their spectral response patterns (Lillesand, et al., 2015, pp. 40). This could be done through satellite imagery using the principles of spectroscopy. Spectroscopic measurement procedures can involve the use of a variety of instruments. Remote sensing is an excellent tool when answering questions within the area of ground emittance as it is greatly valued when conducting research in inaccessible zones and will give accurate and timely assessment of the impacts of the pollutions, as described in the above literature review (Bermann, 2023, Assareh, 2018). This form and style of information can provide insight into how toxic pollution directly affects the air quality, sometimes even more efficiently and thoroughly than field observations (Ibid., 2011). Time series of satellite images will be used to monitor tropospheric gases over a longer period to record changes resulting in effects of methane emissions due to climate change.

4.2 Using the TROPOMI Instrument for a Spectroscopic Analysis

To answer the research questions, remotely sensed satellite data will be used to examine the impacts of methane emissions and its outcome on air quality, also called a spectroscopic analysis, which determines the chemical constitution of substances. Remote sensing is a useful tool here, as the derived information can provide insight into how toxic gasses directly affect the air quality and indirectly leads to changes in human health (CCAC, 2021, Bermann, 2023). As mentioned in the introduction, a Tropospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor has been demonstrated to be effective in detecting ground-level methane emissions (Altaweel, 2022). The instrument is a space-borne, nadir-viewing, imaging spectrometer covering wavelength bands between the ultraviolet and visible, near-infrared and shortwave infrared spectral, and has spatial resolution of about 50 square kilometres (ESA, 2023, NASA, 2023). Using satellite imagery to quantify ground level methane emissions is highly beneficial to support climate change mitigation and human rights justification (Gorrono, 2022).

The instrument, which is installed on the Sentinel-5P spacecraft, uses passive remote sensing techniques – specific sensors that measure the acquired quantity with multiple band combinations – to achieve its objective by measuring solar radiation reflected by and radiated from the Earth's surface (ESA, 2023, NASA, 2023). The instrument is configured in a push-broom mode, covering a swath width of approximately 2600 km on the Earth's surface. The average pixel size at near nadir is 7x3.5 km2 for all spectral bands, except for the UV1 band (7x28 km2) and SWIR bands (7x7 km2) (Ibid., 2023). This kind of visual interpretation comes with its disadvantages in that it may require extensive training and is labour intensive. Additionally, objects may be misinterpreted, and distortions may occur in an image due to the relative motion of sensor and source (Lillesand, 2015, pp. 31).

The study will first monitor methane gas emissions by looking at satellite images of the Arctic within the timeframe of 2018 to 2023. Then, the study will monitor change in air pollution within the timeframe of 2018 to 2023. It is only possible to use the TROPOMI instrument from 2018 and onwards. Sentinel-5, on which the instrument is installed, was launched late 2017 and can therefore not provide a reliable mean from that year. Although, this timeframe does not stretch over generations, it will still show reliable and clear evidence of far-reaching and fast-growing toxic emissions in the Arctic within the timeframe and its impacts as slow violence. Examples of slow violence include cancerous diseases, respiratory diseases, loss of food sources and homes for livestock and humans, loss of biodiversity. Environmental disasters can happen within a short timeframe, but the slow and violent effects will last decades and generations.

'Monitoring' describes the process of finding and analysing satellite images of chosen areas to observe the environment (Lillesand, et al., 2015). This process will later be described in detail. The study will be carried out in this way to quantify ground-level methane emissions to support claims of toxic pollutants and its rapid spread around the world. This is done to highlight how marginalised communities and vulnerable populations are disproportionately affected by toxic pollutants and environmental degradation in order to contribute to the general agreement among scholars that methane emissions deteriorate the health of both plants and people (Schell, et al., 2003, CCAC, 2021, UNEP, 202, State of Global Air, 2019, WHO, 2015).

4.3 Data collection

Free and publicly available data was selected to facilitate this practical and affordable long-term monitoring procedure. The criteria for the selection of suitable data and geographic extent were NADIR viewing angle (the angle of the satellite in relation to the study area) – which, in this case, is directly down – as well as a broad band visualisation and palette. This will be explained in depth on the following pages.

The maps generated by the Copernicus Sentinel-5P give insight into where these gases are coming from (ESA, 2019). All mapping conducted for this study was done through the Google Earth Engine (GEE) software platform. GEE uses cloud computing technology to produce and process geospatial data and imagery by a generated script code (Google Earth Engine, 2022). It currently contains more than 5 petabytes of data that can be accessed, processed and mapped from all over the world, saving researchers a significant amount of hard drive space and download time. This makes GEE one of the most accessible and versatile remote sensing tools available today (Ibid., 2022). GEE is therefore essential for a project of this magnitude as a thorough analysis and gathering of satellite data was needed for sufficient results.

Through the software's Application Program Interface (API), a JavaScript code was used to generate the desired maps needed for the study area. The code used in this project was mainly focused on generating a set of imagery, showing annual average methane gas emission of the Arctic from January 2019 to December 2022. Using a world map viewer within GEE, the case study area could be accurately pinpointed using the TROPOMI instrument onboard the Sentinel-5P. The code editor was then used to generate S-5P satellite imagery for a given period of time. For this particular study, it is not possible to go further back in time than 2018 since the satellite was launched late 2017. With the time period stated, the following functions of the code were focused on displaying a median value for the pixels in the given area. These functions assured that the generated imagery would represent an average pixel value for the given time period.

A step-by-step description of figure 1 and how the data was collected is now given. The maps showcasing the annual emissions were created by using an interpolated (a technique to estimate the values of unknown data points that fall in between existing, known data points) surface of methane concentration by sampling an annual emission average of each year studied (2019-2022). When creating these images with GEE, certain codes were vital in order to create the most accurate data. First step is to determine the measuring device. This study used Sentinel-5P as indicated in the following code, along with the codename for the device and instrument (Copernicus/S5P/OFFL/L3_CH4), which indicates that the TROPOMI instrument is in use, and looks as follow:

Figure 1 - JavaScript coding sample in GEE

Code two determines the selected bands of the images – in this instance methane, column, volume, mixing, ratio, dry and air. The measurement of methane is expressed as a “dry air mole fraction”, which represents the ratio of methane molecules to the total number of molecules in the sample. This calculation is performed after eliminating the influence of water vapor from the measurement (Lan, 2023). Code three reveals the chosen time period. For each image conducted, code three would have to be altered according to the time period.

The next codes are more in depth. Code 5-9 define the band visualisation (band_viz) arguments of the study, meaning that the TROPOMI instrument detects methane by parts per billion (PPB), 1 ppb indicates that one out of every billion molecules in an air sample is CH_4. This study examines values with a minimum of 1650 PPB and a maximum of 1950 PPB. These PPB are classified using the colours black, purple, blue, cyan, green, yellow, orange, red, maroon. 1650 PPB is classified as the lowest value in the study and constitutes the colour purple, while 1950 PPB is classified as the highest value in the study and constitutes the colour maroon as shown in figure 2:

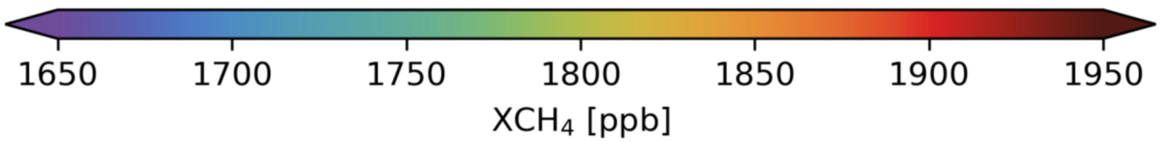

Figure 2, image of band visualisation retrieved from the European Space Agency, 04/03/2019)

Code 11-12 reveal which layers are displayed on the map. These layers include the mean methane emissions within the timeframe as well as the band visualisation (the colour scheme). This means that the last two codes found the mean concentration of methane emissions within the study time frame.

The pictures created using this method look as follows.

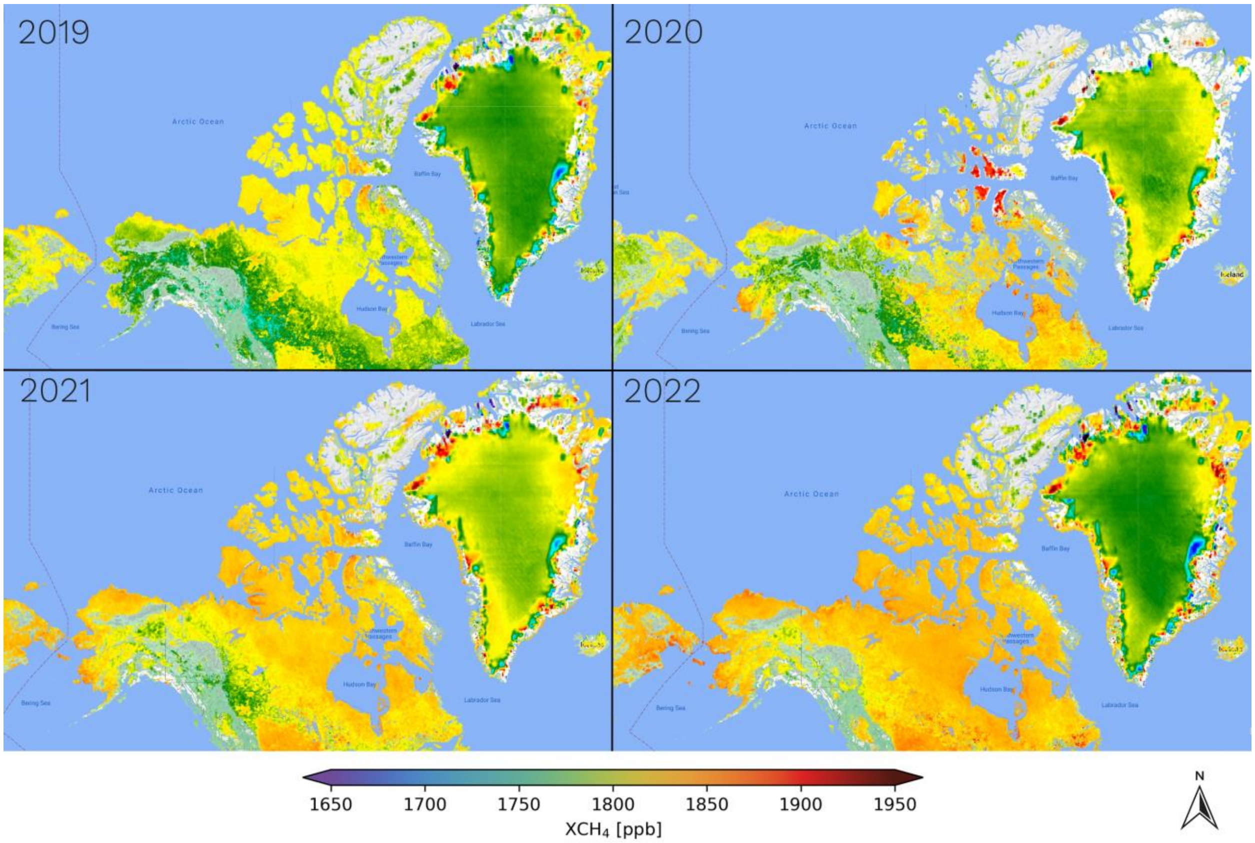

Figure 3 of study area (a), Alaska, northern Canada and Greenland: Temporal change in CH_4 *values in the Arctic. TROPOMI spatial distribution maps derived from Sentinel-5P median image collections of each year represented. Sourced from GEE. Cartography done by: Sigrid Vestergaard and Elías Arnar.*

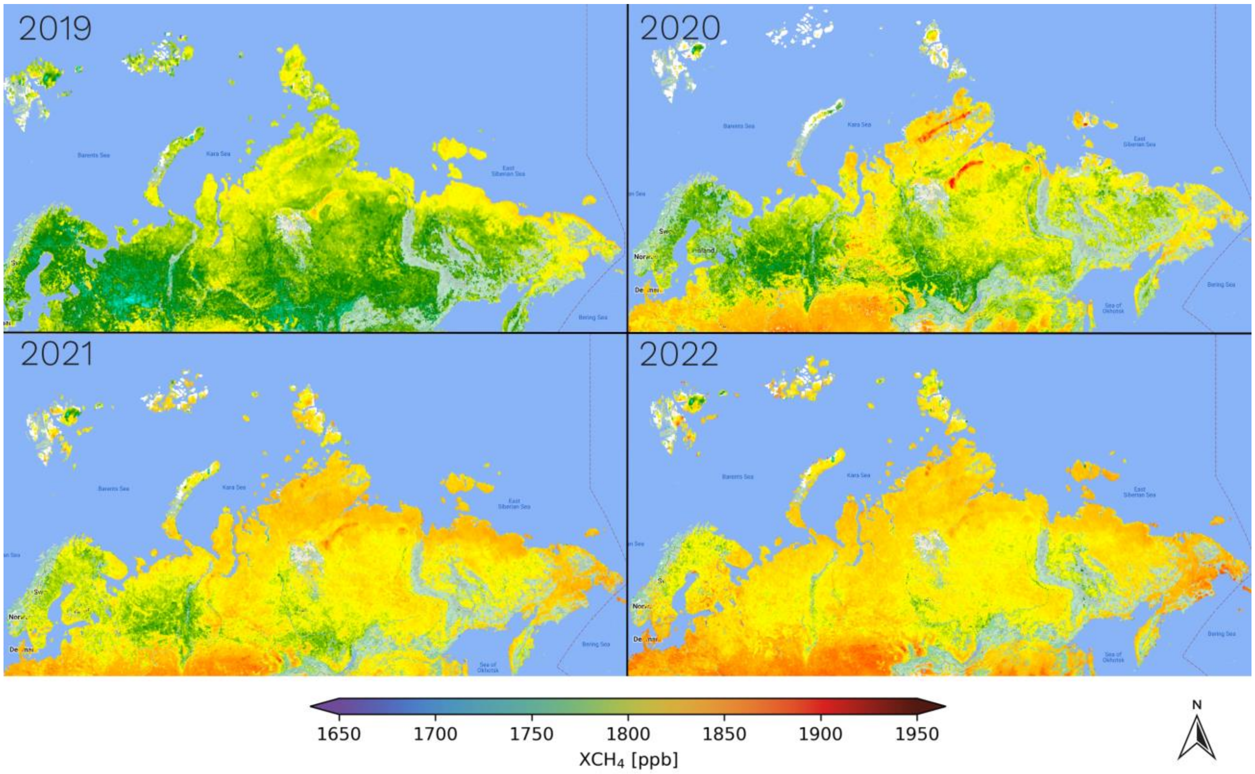

Figure 4 of study area (b), The Nordics and Siberia: Temporal change in CH_4*values in the Arctic. TROPOMI spatial distribution maps derived from Sentinel-5P median image collections of each year represented. Sourced from GEE. Cartography done by: Sigrid Vestergaard and Elías Arnar.*

To examine these images, the band visualisation is vital as it shows the concentration of the emission level which is an empirical approximation of atmospheric gases. The band visualisation was able to apply accurate colours to figure 3 and 4, this is because the imaging spectrometer covers wavelength bands between ultraviolet and visible, near-infrared and shortwave infrared spectral, and created values that gave better visual representation of the gases for S-5P (ESA, 2023, NASA, 2023). Figure 3 shows an overall significant emission increase in the Arctic study areas of Northern Canada and Greenland from 2019 to 2022. Decrease in emissions happened in the centre of Greenland from 2022 to 2023, while Canada shows a rapid increase throughout all four years. Figure 4 likewise shows an overall significant emission increase (high emission being the yellow, orange and red colour, while green nonetheless represents a high level of methane emissions, yet not on the same level) in the study area of Siberia.

4.4 Validity and reliability

Validity raises the matter of whether or not remote sensing and other data collection devices measure the variables we think to measure. It refers to the degree in which our measuring device is truly measuring what the researchers intend it to measure. Reliability refers to whether the measurement devices measure the variables in the same way (quantity) for each observation, or the same way each time or place it is used. (Bhatta, 2013). Validity and reliability in remote sensing research is involved in two instances: First in the observations and then the results from analysis. Therefore, the validity and reliability of data are crucial when employing measuring devices as part of the data collection process.

It is important to mention here, that the year 2018 had to be excluded from the data collection in both maps. S-5P showed an abnormally low TROPOMI value which did not represent reality. It is impossible to know why this happened, as the images were generated with an average of hundreds of images blended together into an average pixel. One explanation could be that an outlaw in the data messed with the pixel average.

The Google Earth Engine is a geospatial processing platform based on geo-information applications in the 'cloud' (Cutillas, 2023). It allows its users to access large amounts of geospatial data combined with artificial intelligence to perform advanced data processing effectively at scale (Codemotion, 2023). The codes applied on this study use the same parameters on all the data. The codes show averages of every year studied and to validate this, they can be compared and supported with literature or other data maps from previous studies.

4.5 Ethical considerations

Although, this study does not conduct interviews or directly observe people, ethics still play a role. The politics of remotely sensed research merge with its ethics. Both are concerned with the normative, and areas of overlap are obvious. Scientific research and evidence are built on a foundation of trust (Bhatta, 2013). Scientists trust that results conducted by others are valid and correct. Society trusts that the results of scientific research reflect an honest attempt to describe the world accurately and without bias. But this trust will endure only if researchers devote themselves to exemplifying the values associated with ethical scientific conduct. This also includes avoiding fraud, tampering of data and results, falsifying, plagiarism and positionality.

5. Presentation of Empirical Material

This chapter presents the analysis of the empirical data for this study, which sets out to explore the role which rapid emissions have on the surrounding communities and how human rights research identifies the issue. For this section, the remotely sensed satellite images will first be overviewed and presented as raw data to provide an objective understanding without interpreting or analysing. This allows the reader to verify the findings or even conduct further analysis if desired. Second, the raw material will be understood by supporting research findings and provide a foundation for the research findings and conclusions. This presentation of raw material will hopefully enable readers to assess the evidence and draw their own conclusions as well.

5.1 Overview of the material

Looking at figure 3 of Alaska, northern Canada and Greenland, it is clear to see an overall pattern of change in emissions between 2019 and 2022, where all three areas have experienced an overall rapid emission increase within the study timeframe. The photo set was analysed with the TROPOMI instrument as explained earlier, and colours were added to emphasise the level of methane emissions in the study areas. The legend tells us that the dark purple colours constitute the lowest value on the legend, namely 1650 ppb of CH_4, the dark red colours constitute the highest value, namely 1950 ppb of CH_4, while light yellow constitutes the mid value, namely 1800 ppb CH_4. Additionally, it is important to clarify that the areas where no colours are detected fall under the studied values of 1650 ppb. Most of the emission increase occurred in the Canadian territories of the Yukon, Northwest Territories and Nunavut along with the American state of Alaska where colours rose from dark green and light yellow to orange. Some rural areas in Alaska even rose to red colours. In numbers, the emissions rose from 1750 ppb to 1850 ppb and 1900 ppb in Alaska between 2019 and 2022. The year 2020 shows an abrupt increase of up to around 1900

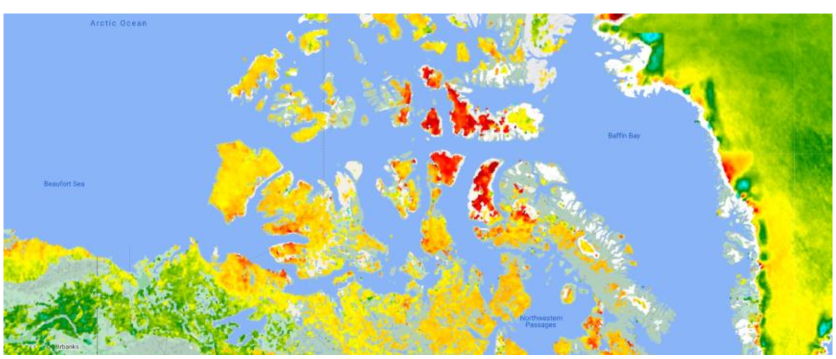

Figure 5 of study area (a), Nunavut Territory, 2020: Abrupt rise in CH_4 values of up to 1900 ppb. TROPOMI spatial distribution maps derived from Sentinel-5P median image collections of each year represented. Sourced from GEE.

ppb in the northern Nunavut Territories but drops to 1850 ppb in 2021 and 2022 as shown in figure 5.

Greenland has experienced a stagnation of high values of 1750 ppb throughout the study period, although, in 2021 emissions rose to 1800 ppb. What is interesting about Greenland is that it shows a constant colour value of green and yellow above the ice sheet compared to Canada and the US which show spotty results. The Greenland coast shows different values all around, even outside towns and villages. Values rise up to almost 1950 ppb in some coastal areas throughout the entire study period, yet the year 2022 shows the highest values around the coast.

Looking at figure 4 of the Nordics and Siberia, it is likewise clear to see an overall rapid pattern of change in emissions between 2019 and 2022, where the Nordics and Siberia both have experienced an overall rapid emission increase within the study timeframe. Most of the emission increase occurred in northern Siberia where colours rose from green and light yellow to orange, with the orange colour stretching further down into the region throughout the study period. In numbers, the emissions rose from 1750 ppb to 1850 ppb from 2019 to 2022. Similar to the Nunavut territory in figure 5, the northern tip of Siberia shows an abrupt increase in 2020 of up to around 1900 ppb but drops to 1850 ppb in 2021 and 2022 as shown in figure 6. The Nordics likewise shows an abrupt increase in emissions rising from 1750 ppb to 1800 ppb and even 1850 ppb in the Arctic region. In 2019 the Nordics shows a constant value of 1750 ppb but closer to 2022 the emissions vary between 1750, 1800 and 1850 ppb.

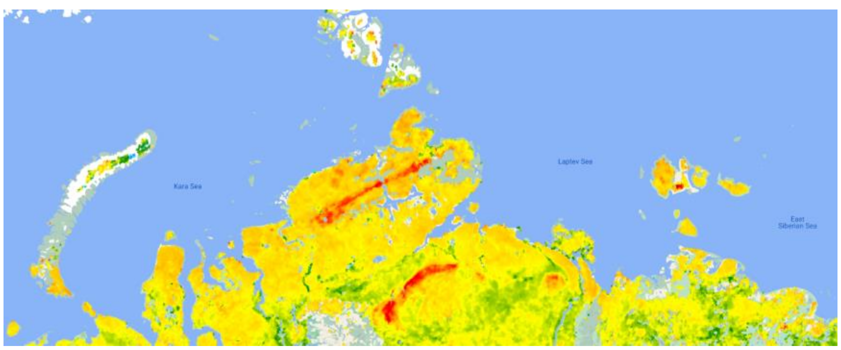

Figure 6 of study area (b), Northen Siberia, 2020: Abrupt rise in CH_4 values of up to 1900 ppb. TROPOMI spatial distribution maps derived from Sentinel-5P median image collections of each year represented. Sourced from GEE.

5.2 Understanding the material

To reiterate, the TROPOMI instrument detects methane by parts per billion (PPB), meaning 1 ppb indicates that one out of every billion molecules in an air sample is CH_4 (methane). Now, this may seem like very little, and, in fact, it can be safe for workers to breathe 1.000 ppb CH_4 on an 8-hour workday, but breathed over a decade can have harmful, slow consequences (CCAC, 2023), as methane is the key ingredient in the destructive air pollutant, tropospheric ozone. Ozone is responsible for circa 1 million premature respiratory deaths globally, while methane is responsible for about half a million (Ibid., 2023).

As mentioned earlier, the research questions this study intends to reveal are significant because – once uncovered – they will demonstrate that there is a crucial connection between the concepts of slow violence, methane gas emissions and human rights. The purpose of this particular study is to shed light on the gaps in the literature and the present knowledge regarding the connection between the three concepts. This study will therefore be able to utilise and grasp the intensity of methane emissions in the Arctic as well as assist in understanding further issues that might emerge due to air pollution. The results will be examined and presented in two parts, first, study area (a) of Alaska, Northen Canada and Greenland, second, study area (b) of the Nordics and Siberia.

From a historical perspective, large methane emissions in the past did not result in destructive global warming for a number of reasons: Methane emissions usually occurred incrementally over an extended period, with each release allowing sufficient time for natural decomposition before another event took place (Carana, 2013). While elevated methane levels in the atmosphere resulted in substantial heat being trapped, the presence of extensive ice acted as a buffer, absorbing the excess heat and preventing it from causing drastic temperature increases (Ibid., 2013). The problem today is that if there are too sudden surges of methane, then the climate cannot keep up and warms rapidly. This then results in glacier surfaces melting away and the ice core and ice sheets begin to lose surface data regressively if there is too much methane in the air (Ibid., 2013). Thus, the current methane melting ice sheets, and 1950 ppb rise is nothing new, except there are no major Pleistocene glaciers to cool the Arctic Ocean if methane goes to overdrive this time. Rapid global warming is now happening as the Arctic loses its methane holding capability due to warming (Ibid., 2013). Today, the increase in both natural and anthropogenic methane emissions reflect a decrease in the atmosphere's ability to break down the gas (Pultarova, 2022). The rapid increase in methane emissions shows that the world is nowhere near on track to slowing down the projected course of climate change. In fact, the continuous release of methane is a vicious cycle that leads to even more anthropogenic warming due to its potent characteristics (Ibid., 2022). The warming is feeding the warming.

5.2.1 Alaska, Northern Canada and Greenland

Methane concentrations show a worrying trend, rapidly rising to a new maximum of nearly 1,950 parts per billion. This is more than 1250 ppb higher than levels reached in pre-industrial times (Carana, 2013). In Alaska and Northern Canada, lakes bubbling with methane are forming as microbes digest the thawing organic matter in anthropogenically melting permafrost (O'Malley, 2022). As explained earlier, the most probable reason for the rapid methane releases in Alaska and Canada is the thawing of permafrost forming thermokarst lakes, which occur when ice wedged into the permafrost melts and creates a crater which eventually fills with meltwater (Ibid., 2022). The methane bubbles can prevent ice from forming on the lakes, which results in the water body continuously releasing methane into the atmosphere. Permafrost freezes soil and plant matter into the ground throughout the entire year, but when it melts, microbes begin consuming the thawed organic substance and releasing methane and carbon dioxide during their digestion. Big Trail Lake is one of Alaska's newest lakes which didn't exist 50 years ago and is one of the largest methane emission hotspots in the north American Arctic (Ibid., 2022). The lake appears normal from a distance, but when you look closely, bubbles can be seen floating to the surface.

Another cause of the rapid methane release could be 'Arctic Sinkholes' found both in Alaska and Siberia. These mysterious massive holes have been appearing across the Arctic landscape, and scientists are still investigating the cause and impacts. As the Arctic warms, the methane that has been locked in permafrost for thousands of years escapes and can explode (Boyce, 2022). Released methane that finds its way to the surface contributes to the greenhouse effect of climate change with even more heat retention capacity than carbon dioxide (Ibid., 2022). Scientists studying this phenomenon find evidence that the Arctic landscape is basically a fossil methane reserve.

Additionally, one reason both figure 5 and 6 show a rapid increase in 2020 and 2021 could be related to the COVID-19 lockdowns (NASA Earth Observatory, 2022). Despite economic data showing that COVID-19-related lockdowns had led to improvements in air quality and reductions in carbon dioxide emissions, tropospheric methane still soared. This could be due to a decline in nitric oxide (NOx), which is an air pollutant released by burning fossil fuels, transportation and industrial activity, and triggers a chain of chemical reactions that produce a reactive compound called hydroxyl (OH). Hydroxyl serves as an atmospheric "detergent" by reacting with methane and removing it from the atmosphere (Ibid., 2022). With no OH in the atmosphere, methane has more space to survive.

Furthermore, the unnaturally warm year of 2021 likewise had a big impact on the rising numbers. This is a worrisome feedback cycle where climate change leads to more intense rains and warmer temperatures, which leads to more methane emissions from wetlands, which leads to even more warming and so on (Ibid., 2022).

As suggested by the figures, the Greenland ice sheet releases a constant high level of methane between 1750 ppb and 1800 ppb at all times. According to new studies (Lamarche-Gagnon, et al., 2019), the Greenland ice sheet releases tonnes of methane into the atmosphere, showing that glacial thaw could be an important global source of this specific greenhouse gas (Andrews, 2019). Most of the Earth's tropospheric methane is created by microorganisms that make organic matter into CH_4 when no oxygen is present, mostly in wetlands and on agricultural land, for example in the stomachs of cows or in rice patties. The remainder comes from fossil fuels (University of Bristol, 2019). Previous instances of methane detection have been documented in Greenland ice cores and Antarctic Subglacial Lakes. However, this marks the first reported occurrence of meltwaters generated in spring and summer within extensive ice sheet catchments consistently releasing methane from the bed of the ice sheet into the atmosphere (Ibid., 2019). Definite proof has been found of a widespread subglacial microbial system, demonstrating the existence of active microorganisms thriving beneath kilometres of ice. These microorganisms not only survive in such extreme conditions but also have the potential to influence other components of the Earth's system. This study reveals that ice sheet beds, characterised by substantial reservoirs of carbon, water and microorganisms, along with limited oxygen, create an ideal environment for the production of methane gas. Moreover, it establishes that these ice sheet beds serve as sources of atmospheric methane (Ibid., 2019).

5.2.2 The Nordics and Siberia

Permafrost covers 11 million square kilometres of Russian Territory. These are rich soils that are full of organic matter and dormant bacteria. When the soil thaws, the old microorganisms wake up and attack what they have not had time to consume when frozen, releasing carbon dioxide when the soil is dry, and methane when it is saturated with water (Markelova, 2022). There is twice as much organic matter in the permafrost as there is in all the flora on the planet. Most of it, equivalent to 1.000 gigatons, is concentrated in the first three metres of the soil. And three metres thaws very quickly. It only takes three to five years. This makes the methane released by permafrost far more dangerous than carbon dioxide (Ibid., 2022). If it were only carbon dioxide that was released from the melting, permafrost emissions would be equivalent to those generated by humans. And since the greenhouse effect of methane is eighty times more powerful than that of CO2 over short periods of time, the climatic consequences of the release of this gas can be up to four times greater than those resulting from the emission of carbon dioxide (Ibid., 2022). Also, in Siberia the COVID-19 lockdowns had an effect on the methane concentration. There has been a historic increase in the concentration of methane during the COVID-19 epidemic (Ibid., 2022).

On Siberia's Yamal Peninsula and Gydan, large Arctic sinkholes have been reported in the frozen tundra bubbling with methane (Boyce, 2022, Pamuk, 2022). This shows that the Siberian Arctic landscape is basically a fossil methane reserve. Gases released from these methane sinkholes are accelerating global warming (Pamuk, 2022). The first known crater formed as a result of methane explosions due to global warming, is more than 24 metres wide and 45 metres deep and holds what may be Siberia's largest natural gas reserve (Boyce, 2022, Pamuk, 2022). Approximately 20 craters have later been registered, appearing due to methane explosions. Before a crater opens up, natural gas, mainly methane, builds up locally under pressure in the shallow permafrost horizons. A gas eruption and formation of a crater are preceded by surface swelling, which turns into a fast-growing pingo, or a dome-shaped mound consisting of a sheet of soil over a large core of ice occurring in permafrost areas (Pamuk, 2022). A gas cavity forming in the upper permafrost horizons before the crater opens up can have a volume of up to one thousand cubic meters. Gas blowout from such a gas-saturated cavity can emit thousands and possibly tens of thousands of cubic meters of methane into the atmosphere (Ibid., 2022).

In 2020, a heatwave hit Siberia and led to new emissions from the permafrost. In the Taymyr Peninsula and its surroundings in North Siberia, the area of the worldwide largest positive surface temperature anomaly for 2020, atmospheric methane concentrations have increased considerably during and after the 2020 heat wave. Two elongated areas of increased atmospheric methane concentration that appeared during summer coincide with two stripes of Palaeozoic carbonates (rock formations) exposed at the southern and northern borders of the Yenisey-Khatanga Basin (Froitzheim, 2021). Other remotely sensed studies indicate that fossil methane gas leaks from exposed limestone known to be hydrocarbon reservoirs after the heatwave, which peaked at 6 degrees Celsius above normal temperatures (Carrington, 2021, Kindy, 2021). Limestone outcrops release ancient methane that has been trapped inside as they heat up from the warming temperatures. Again, if the climate crisis worsens and temperatures continue to rise, large methane releases from rock formations and exposed limestone likewise remain a possibility in the long term.

In Lapland, methane sources include wetlands, peatland and lakes. In Lapland, peatlands are disappearing. They are crucial in tackling the climate crisis as they function as natural carbon sinks (Yle, 2023). Roughly a third of Northern Lapland's peatlands have disappeared since the 1990s due to climate change. These peatlands are formed around permafrost, and with temperatures rising and the permafrost melting, the swamps and carbon sinks have begun to disappear (Ibid., 2023). In 2022, Finland’s land usage started emitting more carbon than it stored. Additionally, damaged peatlands are slowly turning into carbon emitters as degradation and overexploitation can cause significant amounts of greenhouse gases to be emitted into the atmosphere. The southernmost peat swamp in the Pallas-Ounas Tunturi area, which was still present in the 1990s, has now completely disappeared (Ibid., 2023). Additionally, Lapland is also experiencing a rising number of thermokarst lakes like Alaska. These thermokarst lakes are also a result of the thawing peatlands (Seppälä, 2003), bogs forming by the thawing of ice-rich soils and are widespread on flats throughout the boreal permafrost zone. These, too, as we see in Alaska, are greenhouse gas sources as they function as century-old carbon deposits. They now become bioavailable and emit more carbon and methane than ever before (Zandt, et al., 2020). Methane emissions are the net result of methane production by methanogenesis and methane oxidation by aerobic bacteria or anaerobic archaea, with high levels of heterogeneity and intricate interactions (Ibid., 2020).

To summarize this chapter, it is evident that methane emissions have continued to increase, and more and more so over the past few years. The Arctic is experiencing immense increases in the natural gas which is potent to warm the climate at a much higher rate than carbon dioxide. As the chapter explains, several methane sources are popping up in the Arctic as the climate heats up, including melting of permafrost creating new lakes bubbling with methane and causing peatlands to disappear, ‘Arctic sinkholes’, ice sheets, COVID-19 related lockdowns, heatwaves, intense rainfalls, etc. Each and every source contribute to health impacts and further global warming with massive amounts of methane gas emissions as shown in figure 3 and 4.

5.2.3 Violent Impacts on Human Rights

Climate change is a health emergency, and the warmer temperatures are worsening ground-level methane and ozone pollution. Methane is considered a volatile organic compound (VOC), and as methane is leaked, it forms ozone and can cause cancer, impact the nervous system, cause birth defects, premature deaths, respiratory and cardiovascular diseases as explained earlier in the literature review (Clean Air Task Force, 2021, American Lung Association, 2022). Everyone's health is at risk from breathing VOCs – this includes healthy adults. Though these air pollutants can travel far away from their source, people who live near the sources are especially vulnerable (American Lung Association, 2022). Increased outdoor exposure in children is associated with heightened vulnerability to toxic pollution, thereby elevating their risk of experiencing asthma attacks, cancer and other health complications. Furthermore, mothers who are exposed to such pollution face an increased probability of giving birth to infants with birth defects (Ibid., 2022).

For Arctic Indigenous communities, these changes in climate have crucial consequences for their well-being, livelihoods, future generations, culture, nutrition etc. (Lynge, 2009, Almonte, 2023, McVeigh, 2021). While methane does not directly cause cancer in humans on its own, it is a key ingredient in the chemical reaction which creates tropospheric ozone. Methane contributes to the growing global background concentration of ozone, an air pollutant associated with cancer and premature deaths when exposed to it long-term (Kim, et al., 2018, West, et al., 2006). Oxidation of methane in the presence of sunlight is responsible for the majority of the ozone formation in the troposphere, ozone in return helps oxidating methane and lets the cycle continue further (West, et al., 2006). The risk of ozone-induced cancer is highest among adults younger than 50 years old, regardless of gender or health-related behaviours, which is of concern for Indigenous communities that already experience numerous cases of obesity due to loss of traditional food sources (Kim, et al., 2018, Coggins, et al., 2021). Furthermore, the Arctic Indigenous communities in the 8 Arctic States (Canada, Greenland, Finland, Iceland, Norway, Sweden, Russia and the U.S) have been found to hold more cancer cells of different kinds than their non-Indigenous fellow citizens. There has been marked an increase in lung, colorectal and female breast cancers, as well as some rare cancers such as nasopharyngeal cancer. Some groups in Alaska and Canada are at higher risk for prostate and breast cancer compared to the rest of the world (Young, et al., 2016). These rapidly increasing cancer cases are due to severe social, economic and environmental changes among the communities. Additionally, ozone can damage the respiratory tract, causing inflammation, irritation symptoms such as coughing, chest tightness and worsening of asthma symptoms (West, et al., 2006). Breathing ozone can shorten the lives of people in higher risk groups such as Indigenous Peoples. Researchers have repeatedly found that the risk of premature deaths increased with higher levels of ozone. Newer research has confirmed that ozone increases the risk of premature death also in the presence of other pollutants (American Lung Association, 2023). Strong evidence proves that ozone exposure is associated with mortality from respiratory diseases and lung-cancer (Kim, et al., 2018).

6. Analysis

The analysis intends to discuss the impact these changes can have on the health and the future of populations inhabiting areas close to methane sources, as well as use the findings from the previous chapter to answer the research questions. This study aims to talk about the importance of using remote sensing in Human Rights studies and how it can be applied on the concept of slow violence. Studying the effects and growth of toxic air pollution – with the use of remote sensing – can help utilise and understand the intensity and expansion of the violent long-term effects and consequences without stepping into hard-to-access Arctic regions (Avtar, 2021). The analysis is divided into three parts: (1) Alaska, Northern Canada, Greenland; (2) the Nordics and Siberia; (3) a discussion.

6.1 Alaska, Northern Canada and Greenland

Inuit communities populating North America face disproportionate health burdens and environmental health risks where permafrost is prevalent, compared to the average North American population (Hoover, et al., 2012, pp. 1645), and are directly affected by methane emissions from permafrost thaw and carbon sinkholes. It is important to recognise that the impacts of methane emissions on Inuit communities are interconnected with broader climate change issues, socioeconomic factors and the need for sustainable and equitable solutions (Ibid., 2012). These prevalent Arctic methane emissions impact the Inuit communities through disruption of traditional livelihoods; Damages of infrastructure and housing; Increased risks to health and safety; Impacts on traditional knowledge and cultural heritage; Contribution to further global climate change.

Approximately ten percent of the Arctic's four million inhabitants who identify as indigenous experience disproportionate risks to these impacts, as they generally live in remote regions and maintain strong links to the environment through subsistence-oriented hunting, herding, foraging and fishing. Methane emissions can lead to changes in the Arctic ecosystem, affecting the availability and distribution of wildlife and fish (Coggins, et al., 2021). This can disrupt traditional hunting and fishing practices, making it more challenging for Inuit communities to sustain their livelihoods and maintain their cultural practices. These injustice implications of climate change in the Arctic are human rights violations and potentially – and unintentionally – environmental genocide (Ibid., 2021).

Permafrost acts as a foundation for infrastructure and housing in Arctic communities. When permafrost thaws due to methane emissions, it can cause the ground to become unstable and lead to ground subsidence and collapse, sinkholes and landslides. This poses significant risks to infrastructure, including roads, buildings and utilities, and can result in damage to homes and community facilities. Inuit communities may face challenges in maintaining and repairing their infrastructure, impacting their quality of life and safety (Ibid., 2021). Additionally, methane emissions' contribution to climate change, leads to warmer temperatures as specified earlier. These changing climates likewise bring along various health and safety risks to Inuit communities. For example, thawing permafrost can result in loss of traditional lands, displacement of communities, damage to important cultural and historical sites, etc. Warmer temperatures can also affect the availability and safety of traditional food sources, leading to food insecurity and potential health issues (Ibid., 2021). As previously mentioned, ground-level ozone damages vegetation and ecosystems by inhibiting the ability of plants to open the microscopic pores on their leaves to breathe. It interferes with the photosynthesis process by reducing the carbon dioxide which the plants need to process in order to release oxygen (IDNR, 2023). Increased levels of ozone lead to reduced growth and survivability of tree seedlings, native plants and increased susceptibility to diseases, pests, harsh weather etc. (Ibid., 2023). The warming of the Arctic likewise leads to permafrost turning to mud where little vegetation can grow. The melting of the sea ice makes it more difficult to fish and hunt whales to support themselves and the local economy in their communities (Nunavut Climate Change Secretariat, 2023). This significantly affects traditional food security and may force Inuit communities to shift from country food to processed store-bought, which is generally unhealthy and extremely over-priced (Ibid., 2023). Moreover, Inuit communities have a deep connection to their lands and rely on traditional knowledge passed down through generations. Methane emissions and the associated changes in the Arctic environment can disrupt ecosystems, affecting the flora, fauna and migration patterns of wildlife. This can challenge the accuracy and reliability of traditional knowledge, making it more difficult for Inuit communities to predict weather patterns, track animals and adapt their practices accordingly. The loss or alteration of traditional knowledge can have profound cultural implications for Inuit communities (Coggins, et al., 2021). Additionally, diseases that can be transmitted from animals to humans ("zoonotic diseases") are expected to rise as temperatures warm. Previously isolated animal species may get in contact with each other when natural barriers such as ice or snow decrease from the warming climate. This can increase the spread of zoonotic diseases (Nunavut Climate Change Secretariat, 2023).

Due to decades of damaging and destructive environmental policy and degradation of the climate and environment, Native communities have been disproportionately exposed to toxic pollution and other health risks – what some activists call "environmental genocide" (Manjeshwar, 2021). Among all ethnic groups in the U.S. and Canada, Native Americans and First Nations face the highest risks of toxic exposure, highlighting the persisting oppression faced by Native communities. This heightened exposure to toxins has resulted in severe and permanent health consequences within Native American communities (Ibid., 2021). Several attributed to poverty, genetics and inadequate health care systems, but in many cases, they are also intensified by exposure to environmental pollutants. In the Arctic, Indigenous communities face disproportionate health burdens originating from environmental pollution in the face of malnutrition and diabetes due to traditional food sources dying out; Respiratory diseases due to a higher level of air pollution; Higher suicide rates due to cultural degradation etc. (Coggins, 2021, Hoover, 2012). These types of slow violence also occur in other states in non-Arctic U.S. and Canada but through industry, agriculture, release of pesticides and other agricultural by-products either close to or on Native reserves (Hoover, 2012). These exposures affect not only current community residents, and those born into these exposed communities, but also generations to come (Ibid., 2012). Because Natives live at the lowest socioeconomic level in Alaska and Canada, they are most at risk for toxic exposure. In fact, all poor inhabitants and people of colour are disadvantaged, although for Natives, these disadvantages are multiplied by dependence on food supplies closely tied to the land and in which toxic materials have been shown to accumulate (Brook, 1998, pp. 105). The degree of toxic exposure in Native communities reflects the US government's tendency to view Native American reservations as replaceable. Since the birth of the U.S. as a country, Native American policy has largely been characterised by violence, abandonment, ignorance and disinvestment – it comes as no surprise that the U.S. government and private companies value profit and resources over the health, growth and well-being of the people it has oppressed for centuries (Manjeshwar, 2021). Although toxic exposure might not seem like an intentional or evil attempt to harm Native American communities, the systemic exploitation of Native land and ignorance to the ensuing health effects represents the country's heartless disregard of some of its most vulnerable citizens. The diseases and deaths triggered by exposure to toxic pollution on Native land serve as an evil reminder of the injustices that have been imposed on Native Americans by the government and private companies for centuries.

Given that slow violence is more or less invisible and that it is impossible to understand issues and ideas that cannot be imagined, the most difficult part of slow violence lies in the fact that it may not be acknowledged at all, or may not be recognised as violence, per se (Sanders, 2015). While slow violence has claimed and continues to claim many lives and traditional ways of living, the fact that it wreaks unnoticeable havoc causes many people and policymakers whose lives have not been directly affected by it to consider it non-existent or harmless at worst or regard it as something that could have a negative impact in the distant future, at best. This apparently universal inability to acknowledge the countless human and ecological casualties of slow violence clearly illustrates the degree of its underrepresentation in crisis management and policy making (Ibid., 2015).

6.2 The Nordics and Siberia

In Finnish Sápmi, the average temperature has risen by 2,3 degrees Celsius since industrial times. If warming continues at this rate, the climate in Sápmi will resemble that of Southern Finland by the end of the century (WWF Arctic Programme, 2023). Climate change impacts are undermining the rights to health, well-being and self-determination of Arctic Indigenous Peoples by affecting their ability to "function" and live as they would choose. For the Sámi in Lapland and Siberia, some of the most significant health impacts stem from the adverse effects on mental health arising from stress and navigating pressures to change their traditional way of life (Coggins, et al., 2021). Other health impacts of concern for the Sámi include forced changes in diet, increased risks of disease outbreaks and mould exposure, health risks to reindeer and Sámi reindeer herders through greater threat of accidents from changes to ice and snow stability, and risks to physical health and cultural well-being through shifts in livelihoods. Health risks related to water quality have also been documented across the Arctic, including increased microbial contaminants, as well as observations of climate changes impacting water quantity (Ibid., 2021). Ecological grief, felt as a result of experienced or anticipated ecological losses, and identity loss have been linked to a diminished ability to engage in traditional activities that contribute to food security and culture, such as travel on the land and subsistence activities, that result from physical changes to the land due to climate change. Ecological grief and identity loss can in some cases also lead to suicide attempts amongst the Sámi communities and Indigenous Peoples in general (Lynge, 2009).

Additionally, Russia's ongoing war in Ukraine furthers the burden upon already vulnerable Arctic ecosystems and its inhabitants, who are at the forefront of climate change impacts. The current state of uncertainty in Russia as a result of the conflict in Ukraine increases geopolitical and economic interests, putting at further risk the fragile Arctic environment and Indigenous Peoples living there (Almonte, 2023). As a result, the growing accessibility to the Arctic due to climate change and the thawing permafrost, as well as the increased interest in its resources exacerbated by the Russian war in Ukraine, puts Arctic ecosystems and traditional livelihoods of

Indigenous Peoples, such as harvesting, fishing and hunting at further risk. In this way, sustainable livelihoods that have been the basis of social, economic, cultural and spiritual life in the Arctic for generations become increasingly threatened. Sámi reindeer herders in Finland, for instance, have had to incorporate several adaptation strategies in everyday herding practices as changes in the Arctic climate affect reindeer feeding patterns. These feeding patterns have likewise been affected by the Russian war in Ukraine due to increased costs and scarcity of wheat and grains necessary for reindeers feeding, as both countries are major producers of these supplies (Ibid., 2023). This is a problem as the natural feed the reindeers feed on are shrinking. There have been mass-starvations of reindeer both in Russia and Norway in the past decade due to climate change and the thawing of permafrost, and the Sámi herders have to go much further inland in the past few years to find grazing ground (McVeigh, 2021). Shrinking grazing lands and changing weather has made the herders' jobs much harder, making it hard to keep the herds together as they spread out more because they cannot find food. The reindeer, which the Sámi population depend on for food, clothing and economy, are losing their habitats (Ibid., 2021). These drastic changes likewise mean that the Sámi population is losing their culture to climate change and is facing an uncertain future.

6.3 Discussion

The empirical material reveals a significant connection between the concepts of slow violence, methane gas emissions and human rights. By examining the empirical data, we can gain insight into the intensity of methane emissions in the different regions of Alaska, Northern Canada, Greenland, the Nordics and Siberia, and understand the potential consequences of air pollution. In these regions, methane concentrations have reached alarming levels, surpassing 1.950 ppb, which is significantly higher than pre-industrial levels (UNEP, 2021). This increase is primarily attributed to the thawing of permafrost, leading to the formation of thermokarst lakes where microbes digest thawing organic matter and release methane into the atmosphere (O'Malley, 2022).

Methane emissions in the Arctic, often overlooked by decision-makers worldwide, can be understood as committing a violent act against the global population. However, the current literature has yet to fully explore and establish the direct link between methane emissions and the broader implications for human rights. This study aims to emphasize the crucial potential and indirect connections between methane emissions, slow violence and their impact on human rights. When we consider the concept of slow violence, as proposed by Nixon (2011), it is evident that environmental breakdown and the consequences of climate change can unfold gradually and slowly. This slow and invisible violence manifests as a deep disconnect between the cause (methane emissions) and the eventual effects on Arctic Indigenous peoples and the environment, their ancestral lifestyles and knowledge which is so strongly integrated with the Arctic landscape. The growing impacts of climate change in the Arctic thus directly affect the life and culture of its inhabitants in the face of decrease of snow cover, thawing permafrost and rapidly melting sea ice (Almonte, 2023). The health and well-being of Arctic Indigenous communities are utterly dependent on what they are able to harvest from the land and the sea around them (Lynge, 2009), and because of this, anything that threatens their subsistence activities threatens their health. The melting permafrost will make it more difficult to freeze their food the traditional ways, and the shifting grounds are damaging their sanitation and water supply systems as well as housing and homes when permafrost turns into mud or the ground collapses (Ibid., 2009). Likewise, tropospheric ozone, as mentioned earlier, is responsible for circa 1 million premature respiratory deaths globally, while methane is responsible for about half a million (CCAC, 2023). The risk of ozone-induced cancer is highest among adults younger than 50 years old, regardless of gender or health-related behaviours, which is of concern for Indigenous communities that already experience numerous cases of obesity due to loss of traditional food sources (Kim, et al., 2018, Coggins, et al., 2021). Furthermore, as previously noted, there has been an increase in lung, colorectal and female breast cancer cases, as well as some rare cancers such as nasopharyngeal cancer within Arctic Indigenous communities. Some groups in Alaska and Canada are at higher risk for prostate and breast cancer compared to the rest of the world (Young, et al., 2016). Ozone is found to damage the tissues of the respiratory tract in humans, causing inflammation and irritation, coughing, chest tightness and worsening of asthma symptoms (West, et al., 2006). Researchers have repeatedly found that the risk of premature deaths increases with higher levels of ozone, and strong evidence proves that ozone exposure is associated with mortality from respiratory diseases and lung-cancer (Kim, et al., 2018).

The breakdown of the climate, driven by methane emissions, can be seen as an act of violence perpetrated against marginalised communities, particularly those already facing socioeconomic challenges, people of colour and future generations. By framing climate change as an issue of slow violence, we shift the focus from short-term, sensational events to the long-term and persistent impacts that erode the rights and well-being of individuals and communities (Nixon, 2011, Curry, 2017). Methane, a colourless and odourless gas, is a potent greenhouse gas that significantly contributes to global warming and climate change. Its role as a key ingredient in the formation of ground-level ozone, poses serious risks to human health. While the individual impact of low-level exposure to air pollutants, including methane emissions and ground-level ozone, may seem minor, the cumulative effect on the global populations is substantial. This is particularly significant for socioeconomically disadvantaged groups, who are often disproportionately exposed to higher levels of pollutants due to environmental inequalities and social injustices (Schell, et al., 2003). This concept and effects are what Nixon coined as slow violence. It is crucial to acknowledge that the impacts of methane emissions and ground-level ozone extend beyond human health. These pollutants also disrupt ecosystems and have far-reaching socio-economic consequences. The human rights implications of these impacts are multifaceted, as they perpetuate environmental inequalities, exacerbate social injustices and disproportionately affect vulnerable populations. By connecting the intensification of climate change resulting from increased methane emissions to the concept of slow violence, we can better understand the gradual devastation faced by communities. As the Arctic permafrost thaws abruptly, releasing greenhouse gasses, including methane, from previously frozen organic matter, the implications for the climate and human health can be seen as a form of slow violence. Environmental disasters, such as the release of methane from permafrost, silently creep up on communities before erupting as calamitous events (Nixon, 2011). It is crucial to recognise the potential indirect links between methane emissions, slow violence, and its impact on Indigenous human health and nature. The gradual and cumulative effects of climate change, including increased methane emissions, can contribute to the erosion of Indigenous communities' well-being (ECHO, 2023, WHO, 2015), disrupt ecosystems (Bhatia et al., 2012, IDNR, 2023), exacerbate environmental inequalities and perpetuate social injustices (CCAC, 2021) over time. These indirect impacts align with the underlying principles of slow violence, even if they are not explicitly labelled as such in the literature. Although they only account for around 5 percent of the world's population, they effectively manage an estimated 20-25 per cent of the Earth's land surface (UN DESASI, 2021). Their land consists of areas that hold 80% of the planet's biodiversity and about 40% of the world's protected areas and its ecologically intact landscapes. Indigenous peoples therefore play a key role in efforts to protect the planet and biodiversity.

7. Conclusion

In regions where permafrost is prevalent, a disproportionate burden of health and environmental risks exist compared to the average non-Arctic regions (Hoover, et al., 2012, pp. 1645). The Indigenous communities living around the permafrost are directly impacted by the release of methane emissions resulting from permafrost thaw, carbon feedback and carbon sinkholes. These phenomena are exacerbated by climate change and can, in return, exacerbate climate change. It is crucial to acknowledge that the consequences of methane emissions around Arctic Indigenous communities extend beyond localized effects and are interconnected with broader climate change challenges, socioeconomic factors and the urgent need for sustainable and equitable solutions (Ibid., 2012). The prevalence of methane emissions in the Arctic significantly impacts Indigenous communities in several ways, Firstly, it disrupts their traditional livelihoods, which are deeply intertwined with the surrounding environment. Secondly, it leads to damages in infrastructure and housing, exacerbating existing challenges and hindering community development. Moreover, the increased risks to health and safety pose significant concerns for the well-being of community members. Additionally, the impacts of methane emissions affect the preservation of traditional knowledge and cultural heritage, which are integral to Indigenous identity and well-being. Lastly, the contribution of methane emissions to global climate change further amplifies the urgency of addressing this issue (Ibid., 2012).

Anthropogenic warming will set free an unknown amount of carbon dioxide and methane from the thawing of the permafrost, exacerbating the climate through heating (Miner, 2022, pp. 55). Abrupt thaw can emit substantial amounts of deeply sequestered carbon to the atmosphere rapidly. Carbon dioxide emissions are proportionally larger than methane gas emissions in the arctic, but methane gas is significantly more potent than carbon dioxide, with over 25 times the heat-trapping capacity in the atmosphere (US Environmental Protection Agency, 2022). Because of this, these emissions are supercharging global warming, climate change and human health globally. Ground-based surveillance and monitoring of methane emissions have been traditionally used but has shown to have limitations due to the geographic scale at which these hotspot emissions exist (Bermann, et al., 2023). Therefore, cost-effective aerial observation methods such as remote sensing satellite monitoring are highly needed to detect the increasing methane emissions. Methane has absorption lines in the infrared spectrum, which is distinct from other gas species, and can be utilized to detect and quantify methane emissions from other interfering components such as water, carbon dioxide and ethane (Ibid., 2023). This study monitored methane gas emissions by looking at satellite images of the Arctic using the Tropospheric Monitoring Instrument (TROPOMI) onboard the Copernicus Sentinel-5 Precursor within the timeframe of 2018 to 2023. Then, the study monitored changes in air pollution within the timeframe of 2019 to 2023. Using satellite imagery to quantify ground level methane emissions is highly beneficial to support climate change mitigation and human rights justifications (Gorrono, 2022). The study was carried out in this way to quantify ground-level methane emissions to support claims of toxic pollutants and its rapid spread around the Arctic regions. This is done to highlight how marginalised communities and vulnerable populations are disproportionately affected by toxic pollutants and environmental degradation in order to contribute to the general agreement among scholars that methane emissions deteriorate the health of both plants and people (Schell, et al., 2003, CCAC, 2021, UNEP, 202, State of Global Air, 2019, WHO, 2015).

The results include: Ground-level ozone damages vegetation and ecosystems by inhibiting the ability of plants to open the microscopic pores on their leaves to breathe. It interferes with the photosynthesis process by reducing the carbon dioxide which the plants need to process in order to release oxygen, meaning increased levels of ozone lead to reduced growth and survivability of native plants (IDNR, 2023). The warming of the Arctic likewise leads to permafrost ground to collapse ad turn to mud where little to no vegetation can grow. The melting of the sea ice makes it more difficult to fish and hunt whales to support themselves and the local economy in their communities (Nunavut Climate Change Secretariat, 2023). This significantly affects traditional food security and may force Inuit communities to shift from country food to processed store-bought, which is generally unhealthy and extremely over-priced (Ibid., 2023). Methane emissions and the associated changes in the Arctic environment can disrupt ecosystems, affect flora, fauna and migration patterns of wildlife. This can challenge the accuracy and reliability of traditional knowledge, making it more difficult for Inuit communities to predict weather patterns, track animals and adapt their practices accordingly (Ibid., 2023).

For Arctic Indigenous communities, these changes in climate have crucial consequences for their well-being, livelihoods, future generations, culture, nutrition etc. (Lynge, 2009, Almonte, 2023, McVeigh, 2021). While methane does not directly cause cancer in humans on its own, it is a key ingredient in the chemical reaction which creates tropospheric ozone. Methane contributes to the growing global background concentration of tropospheric ozone, an air pollutant associated with cancer and premature deaths (Kim, et al., 2018, West, et al., 2006). The risk of ozone-induced cancer is highest among adults younger than 50 years old, regardless of gender or health-related behaviours, which is of concern for Indigenous communities that already experience numerous cases of obesity due to loss of traditional food sources (Kim, et al., 2018, Coggins, et al., 2021). Furthermore, the Arctic Indigenous communities have been found to hold more cancer cells of different kinds than their non-Indigenous fellow citizens. There has been marked an increase in lung, colorectal and female breast cancers, as well as some rare cancers such as nasopharyngeal cancer. Some groups in Alaska and Canada are at higher risk for prostate and breast cancer compared to the rest of the world (Young, et al., 2016). These rapidly increasing cancer cases are due to severe social, economic and environmental changes among the communities. Additionally, ozone can damage the respiratory tract, causing inflammation, irritation and symptoms such as coughing, chest tightness and worsening of asthma symptoms (West, et al., 2006). Breathing ozone can shorten the lives of people in higher risk groups like Indigenous Peoples. Researchers have repeatedly found that the risk of premature deaths increases with higher levels of ozone. Strong evidence proves that ozone exposure is associated with mortality from respiratory diseases and lung-cancer (Kim, et al., 2018).

Approximately ten percent of the Arctic’s four million inhabitants who identify as Indigenous experience disproportionate risks to these impacts, as they generally live in remote regions and maintain strong links to the environment through subsistence-oriented hunting, herding, foraging and fishing. Slow violence is connected to environmental justice because the relating threats to human and environmental health is experienced unequally by wealthy and impoverished communities (Nixon, 2011). One can only be ethical towards the things we can see, feel, understand, love or have faith in – which emphasizes the importance of exposing the ongoing injustices of slow violence in a way that not only describes their effects in detail but also enhances public awareness thereof (Sanders, 2015). It is crucial to effectively realise that traditional lifestyles of several Indigenous communities have been harmed by the dire consequences of the ongoing climate crisis. Making the unseen come into clear view while also bringing humanity into the equation, can be seen as a direct answer to Nixon's recurring question of how one can effectively turn the catastrophic calamities of slow violence into stories powerful enough to stimulate public sentiment and assure political action (Ibid., 2015).

Existing literature overlooks the consequences of methane emissions' social and cultural impacts within the Arctic regions. Slow violence, in the face of methane emissions could have cumulative social and chronic impacts on local, Indigenous communities and vulnerable ecosystems (UN DESAIP, 2023). To reiterate, disproportionate pollutant exposure by socioeconomically disadvantaged groups exacerbates risk of poor health and wellbeing (Schell, et al., 2003, pp. 111). Indigenous peoples are amongst the first people to face the direct and harmful consequences of climate change, due to their dependence on, and close relationship with, the environment and its resources (Ibid., 2023). Climate change multiplies the difficulties which indigenous communities are already facing. including political and economic marginalisation, loss of traditional land and resources, human rights violations, etc. – all examples of slow violence (Ibid., 2023).

7.2 Policy Recommendations

Studying the policy and governance responses to slow violence caused by methane gas emissions in the Arctic could be an essential aspect of addressing this gap. This could involve examining the effectiveness and adequacy of existing mitigation measures, regulations and international agreements on mitigating slow violence and ensuring social and environmental justice for affected communities (Nixon, 2011) like Indigenous peoples in the Arctic. Climate change mitigation and adaptation are a question of human rights for Indigenous peoples in the Arctic (WWF Arctic Programme, 2023). Policy recommendations on Arctic health could include: Reducing or eliminating contaminants at its source – Arctic states should take steps to reduce or eliminate chemicals and emissions; Monitoring and addressing food insecurity in Arctic communities – governments and NGOs should take an active role in monitoring food insecurity and collaboratively develop proactive approaches to address it, building on and learning from existing practices and models; Expanding efforts to research the exposure, dietary transitions and health impacts to monitor the drastic development (AMAP, 2021). One of the main achievements of the United Nations human rights system was the General Assembly's adoption in 2007 of the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). It applies human rights to Indigenous peoples and their specific situations, thereby helping to reverse their historical exclusion from the international legal system (UNOHCHR, 2013). International activity on Indigenous peoples' issues has been expanding also into regional human rights bodies, such as the African and Inter-American human rights systems, and into international law and policy areas as diverse as the environment including climate change, intellectual property and trade.

Policy recommendations on how to reduce methane emissions and permafrost thaw could include: Implementing general progress of actions to reduce emissions of diesel-powered sources; Adopting and implementing oil and gas methane emission reduction strategies; Reducing emissions from new solid fuel combustion appliances by accelerating usage of cleaner and more efficient heating sources; Also avoiding methane emissions by preventing food waste and landfilling of organic waste; Promoting food consumption patterns that utilise Arctic food chains sustainably and efficiently, while supporting the preservation of carbon sinks and minimising life-cycle emissions of methane; And lastly, urging firms to engage in international and domestic voluntary methane and black carbon emission reduction activities, including the implementation of methane management strategies, such as international partnerships and technological strategies like remotely sensed and transparent data (Arctic Council Secretariat, 2021, pp. 22-52). On a daily basis, political decisions are made, often with their full extent of impact being unclear. Often, the decisions and policy measures implemented result in direct unintended negative impacts, such as on the natural environment, which can vary in time, space, nature and severity. To achieve a more sustainable world with equitable societies requires fundamental rethinking of our policymaking. It calls for informed decision making and a monitoring of political impact for which evidence-based knowledge is necessary. The most powerful tool to derive objective and systematic spatial information and, thus, add to transparent decisions is remote sensing (Bell, et al., 2023). By examining the slow violence inflicted on these communities, for example through remote sensing, human rights studies can shed light on the underlying structures and power dynamics that perpetuate inequality and discrimination (Shred-Hewitt, 2021). By addressing the interconnections between slow violence, remote sensing and human rights, this research underscores the urgent need for equitable environmental policies, sustainable resource management and social justice initiatives. The findings of this study will contribute to the growing body of knowledge on the intersection of environmental harm, human rights and the responsibility of decision-makers to protect vulnerable communities.

Ultimately, this research has sought to foster a more inclusive and rights-based approach to addressing the far-reaching consequences of slow violence on both human and environmental well-being. By recognizing the multifaceted impacts of methane emissions on Arctic Indigenous communities, we can better comprehend the interconnectedness of climate change, socioeconomic factors and the imperative for sustainable and equitable solutions. It is essential to prioritize the development and implementation for strategies that mitigate methane emissions, protect the well-being of Indigenous communities and foster a resilient and sustainable future. Addressing the challenges faced by Indigenous communities requires a comprehensive approach that incorporates environmental, social and economic dimensions, while listening to the voices and needs of the affected communities. Indigenous peoples across the globe are stewards of the world's biodiversity and cultural diversity and their voices are absolutely crucial.

8. References

Articles:

Aminzadeh, S. (2007). *A Moral Imperative: The Human Rights Implications of Climate Change*, Hastings International and Comparative Law Review, 30(2), pp. 231-266.

AMAP, Arctic Monitoring and Assessment Programme. (2021). *Human Health in the Arctic 2021*, Summary for Policy Makers, available at: https://oaarchive.arctic-council.org/handle/11374/2624

Andrews, L. (2019). *Greenland's Subglacial Methane Released*, NASA, Global Modelling and Assimilation Office, pp. 1-2.

Arctic Council Secretariat. (2021). *Expert Group on Black Carbon and Methane*, EGBCM, pp. 22-52, available at: https://oaarchive.arctic-council.org/handle/11374/2610

Avtar, R., Kouser, A., Kumar, A. (2021). *Remote Sensing for International Peace and Security: Its Role and Implications*, Assessing Sustainability over Space and Time: The Emerging Roles of GIScience and Remote Sensing, MDPI, vol. 13, no. 3.

Bell, A., Klein, D., Rieser, J., Kraus, T., Thiel, M., Dech, S. (2023). *Scientific Evidence from Space - A Review of Spaceborne Remote Sensing Applications at the Science-Policy Interface*, University of Würzburg, Am Hubland, vol. 15, no. 14, pp. 940.

Bermann, E., McFadden, N., Aubrun, F., Larive, M. (2023). *Importance of Methane Detection and the Use of Infrared to Detect Methane Leak*, Xenics Infrared Solution, Kairos Aerospace, vol. 1, pp. 1-2.

Bhatia, A. et al. (2012). *Impact of Tropospheric Ozone on Crop Growth and Productivity – a Review*, Journal of Scientific and Industrial Research, vol. 71, February 2012, pp. 97-112.

Brook, D. (1998). *Environmental Genocide: Native Americans and Toxic Waste*, The American Journal of Economics and Sociology, vol. 57, no. 1, pp. 105-113.

Canadian Climate Institute, The. (2022). *The Impacts of Permafrost Thaw on Northern Indigenous Communities*, The Firelight Group, Firelight Research Inc. Vancouver, B.C., available at: https://climateinstitute.ca/reports/the-impacts-of-permafrost-thaw-on-northern-indigenous-communities/

Codemotion. (2023). *What is Google Earth Engine and Why It is Key for Sustainability Data Analysis,* Codemotion, available at: https://www.codemotion.com/magazine/data-science/what-is-google-earth-engine-and-why-its-key-for-sustainability-data-analysis/

Coggins, S., Ford, J. (2021). *Indigenous Peoples and Climate Justice in the Arctic,* SFS Georgetown Journal of International Affairs, Society and Culture, available at: https://gjia.georgetown.edu/2021/02/23/indigenous-peoples-and-climate-justice-in-the-arctic/

Cutillas, P., Pérez-Navarro, A., García, C., Zema, D. (2023). *What is Going on Within Google Earth Engine? A Systematic Review and Meta-Analysis,* Remote Sensing Applications, Society and Environment, Research Gate.

Davies, T. (2019), *Slow Violence and Toxic Geographies: 'Out of Sight' to Whom?,* Politics and Space, 2022, vol. 40(2), pp. 409-427, Sage Publications.

Douglas, T. et al., (2020). *Increased Rainfall Stimulates Permafrost Thaw across a Variety of Interior Alaskan Boreal Ecosystems,* NPJ Climate and Atmospheric Science 3, 28.

Elder, C. D., Thompson, D. R., Thorpe, A. K., Chandanpurkar, H. A., Hanke, P. J., Hasson, N., et al. (2021). *Characterizing Methane Emission Hotspots From Thawing Permafrost, Global Biochemical Cycles,* AGU Advancing Earth and Space Science, vol. 35, pp. 1-22.

Froitzheim, N., Majka, J., Zastrozhnov, D. (2021). *Methane Release from Carbonate Rock Formations in the Siberian permafrost area during and after the 2020 heat wave,* Earth, Atmospheric and Planetary Sciences, PNAS, vol. 118, pp. 1-3.

Galtung, J. (1990). *Cultural Violence,* Journal of Peace Research, Jstor, vol. 27, no. 3, pp. 291-305.

Gorroño, J., Varon, D., Irakulis, I., Guanter, L. (2022). *Understanding the Potential of Sentinel-2 for Monitoring Methane Point Emissions,* EGU, Atmospheric Measurement Techniques, pp. 1-25.

Hoover, E. Cook, K., Plain, R. (2012). *Indigenous Peoples of North America: Environmental Exposures and Reproductive Justice,* Environmental Health Perspectives, National Library of Medicine, vol. 120, no. 12, pp. 1645-1649.

Kim, K., Shin, J., Choi, J. (2018). *Cancer Risk From Exposure to Particulate Matter and Ozone According to Obesity and Health-Related Behaviours: A Nationwide Population-Based Cross-Sectional Study,* Cancer Epidemiol Biomarkers Prev., National Library of Medicine, National Center for Biotechnology Information, vol. 28, no. 2, pp. 357-362.

Lamarche-Gagnon, G., Wadham, J., Sherwood, B., et al. (2019). *Greenland Melt Drives Continuous Export of Methane From the Ice-Sheet Bed,* Nature, vol. 565, pp. 73-77.

Lynge, A. (2009). *Climate Change - a Challenge for the Arctic Indigenous Peoples - The Inuit Response,* IOP Conference Seriese: Earth and Environmental Science, vol. 8, pp. 1-3.

Mendes, W., et al. (2022). *A Remote Sensing Framework to Map Potential Toxic Elements in Agricultural Soils in the Humid Tropics*, Environmental Pollution, Elsevier, ScienceDirect.

Miner, K. et al., (2022). *Permafrost Carbon Emissions in a Changing Arctic*, Nature Reviews, Earth & Environment 3, pp. 55-67.

O'Malley, I. (2022). *Methane "Belching" Lakes Discovered in Alaska as Permafrost Thaws,* The Weather Network, Climate, September 29th, available at: https://www.theweathernetwork.com/en/news/climate/impacts/methane-belching-lakes-discovered-in-alaska-as-permafrost-thaws

Sanders, S. (2015). *Slow Violence Fast-Forwarded: Inuit Knowledge and Climate Change,* Humanist Perspectives, Global Temperature Changes Violence, The Free Library by Farlex, available at: https://www.thefreelibrary.com/Slow+violence+fast-forwarded%3A+Inuit+knowledge+and+climate+change.-a0437059096

Seppälä, M. (2003). *Thermokarst Ponds as Indicators of the Former Distribution of Palsas in Finnish Lapland*, Permafrost and Periglacial Processes, ResearchGate, vol. 14, no. 1, pp. 19-27.

Schell, L., Denham, M. (2003). *Environmental Pollution in Urban Environments and Human Biology,* Annual Review of Anthropology, Annual Reviews, vol. 32, pp. 111-134.

UNOHCHR. (2013). *Indigenous Peoples and the United Nations Human Rights System*, Fact sheet no. 9, rev. 2, pp. 1, available at: https://www.ohchr.org/Documents/Publications/fs9Rev.2.pdf

Usman, M., Xu, C., Van Bavel, B. (2021). *Global Inequality Remotely Sensed,* PNAS, Proceedings of the National Academy of Sciences of the United States of America, vol. 118, no. 18, pp. 1-6.

Walter Anthony, K., Schneider von Deimling, T., Nitze, I. et al. (2018). *21st-Century Modelled Permafrost Carbon Emissions Accelerated by Abrupt Thaw Beneath Lakes,* Nature Communications 9, 3262, pp. 1-9.

West, J., Fiore, A., Horowitz, L., Mauzerall, D. (2006). *Global Health Benefits of Mitigating Ozone Pollution with Methane Emission Controls,* Environmental Sciences, PNAS, vol. 103, no. 11, pp. 3988-3993.

World Health Organization. (2015). *Chapter 2: Health Effects of Ground-Level Ozone*, Reducing Global Health Risks – Through Mitigation of Short-Lived Climate Pollutants, vol. 1, pp. 32-34.

Young, T., Kelly, J., Friborg, J., Soininen, L., Wong, K. (2016). *Cancer Among Circumpolar Populations: An Emerging Public Health Concern*, National Library of Medicine, vol. 75, available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4712322/

Zandt, M., Liebner, S., Welte, C. (2020). *Roles of Thermokarst LAkes in a Warming World,* Trends in Microbiology, Science Direct, vol. 28, no. 9, pp. 769-779.

Books:

Bhatta, B. (2013). *Research Methods in Remote Sensing*, Springer Briefs in Earth Sciences, Springer.

Lillesand, T., Kiefer, R., Chipman, J. (2015). *Remote Sensing and Image Interpretation*, vol. 7, Wiley Publications, USA. pp. 31-32.

Nixon, R. (2011). *Slow Violence and the Environmentalism of the Poor,* Harvard University Press, ProQuest Ebook Central, pp. 6-44, 128-149.

United Nations Economic Commission for Europe, UNECE. (2003). *Environmental Monitoring and Reporting*, Eastern Europe, the Caucasus and Central Asia, United Nations, New York, Geneva.

News articles:

Almonte, M. (2023). *Vulnerability in the Arctic in the Context of Climate Change and Uncertainty,* The Arctic Institute, Center for Circumpolar Security Studies, available at: https://www.thearcticinstitute.org/vulnerability-arctic-context-climate-change-uncertainty/

Barnwell, G., Heleta, S. (2021). *The Slow Violence of Climate Change*, The American University in Cairo, School of Global Affairs and Public Policy, available at: https://www.thecairoreview.com/essays/the-slow-violence-of-climate-change/

Boyce, R. (2022). *Nova Episode Explores Arctic Methane Explosions*, UAF News and Information, January 31st, available at: https://www.uaf.edu/news/nova-episode-explores-arctic-methane-explosions.php

Carrington, D. (2021). *Climate Crisis: Siberian Heatwave Led to New Methane Emissions, Study Says,* The Guardian, Climate Crisis, August 2nd, available at: https://www.theguardian.com/environment/2021/aug/02/climate-crisis-siberian-heatwave-led-to-new-methane-emissions-study-says

European Space Agency, ESA. (04/03/2019). *Methane and Ozone Data Products From Copernicus Sentinel-5P,* The European Space Agency, available at: https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-5P/Methane_and_ozone_data_products_from_Copernicus_Sentinel-5P

Kindy, D. (2021). *Permafrost Thaw in Siberia Creates a Ticking 'Methane Bomb' of Greenhouse Gases, Scientists Warn*, Smithsonian Magazine, August 5th, available at: https://www.smithsonianmag.com/smart-news/ticking-timebomb-siberia-thawing-permafrost-releases-more-methane-180978381/

Manjeshwar, S. (2021). *The Lasting Harms of Toxic Exposure in Native American Communities*, Berkeley Political Review, July 10th, available at: https://bpr.berkeley.edu/2021/07/10/the-lasting-harms-of-toxic-exposure-in-native-american-communities/

McVeigh, K. (2021). *"This New Snow Has no Name": Sámi Reindeer Herders Face Climate Disaster*, The Guardian, December 17th, available at: https://www.theguardian.com/society/2021/dec/17/new-snow-no-name-sami-reindeer-herders-climate-disaster

Pamuk, D. (2022). *Methane Blowout Crates in Siberia are 'Canary in a Coal Mine for Global Climate',* AA.com, World Environment, September 16th, available at: https://www.aa.com.tr/en/environment/methane-blowout-craters-in-siberia-are-canary-in-a-coal-mine-for-global-climate-/2686703

Schreiber, M. (2018). *The Race to Save Arctic Cities as Permafrost Melts,* Bloomberg, May 10th, available at: https://www.bloomberg.com/news/articles/2018-05-10/melting-permafrost-and-the-housing-crisis-in-the-arctic

Shred-Hewitt, B. (2021). *Slow Violence, Uneven Earth*, Where the Ecological Meets the Political, March 29th, 2021, available at: https://unevenearth.org/2021/03/slow-violence/

Tollefson, J. (2018). *Satellite Spies Methane Bubbling up From Arctic Permafrost*, Springer Nature Limited, available at: https://www.nature.com/articles/d41586-018-07751-w

University of Bristol. (2019). *Melting Ice Sheets Release Tons of Methane Into the Atmosphere, Study Finds,* Phys.org, available at: https://phys.org/news/2019-01-ice-sheets-tons-methane-atmosphere.html

Yle News. (2023). *Metsähallitus: Lapland Losing Peatlands to Climate Change,* Yle News, February 28th, available at: https://yle.fi/a/74-20020095

Websites:

Altaweel, M., (2022). *Detecting Methane With Satellites,* Maps and Cartography, GIS Lounge, February 16th, 2022, available at: https://www.gislounge.com/detecting-methane-with-satellites/

American Lung Association. (2023). *Ozone,* American Lung Association, April 17th, available at: https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/ozone

American Lung Association. (2022). *Why Everyone Should Care About Methane Gas Pollution*, Each Breath, American Lung Association, February 24th, available at: https://www.lung.org/blog/methane-gas-pollution

Assareh, N. (2018). *Remote Sensing of Methane Emissions,* Regen Network, Medium, May 2nd 2018, available at: https://medium.com/regen-network/remote-sensing-of-methane-emissions-2d849cf68fd7

Carana, S. (2013). *Mean Methane Levels Reach 1800 ppb*, Arctic News, June 18th, available at: http://arctic-news.blogspot.com/2013/06/mean-methane-levels-reach-1800-ppb.html

CCAC Secretariat, (22/03/2021). *Methane's Links to Respiratory Diseases Strengthens the Case for its Rapid Reduction*, Climate and Clean Air Coalition, available at: https://www.ccacoalition.org/en/news/methane%E2%80%99s-links-respiratory-diseases-strengthens-case-its-rapid-reduction

CCAC. (2023). *Methane*, Climate and Clean Air Coalition, available at: https://www.ccacoalition.org/en/slcps/methane

Clean Air Task Force. (2021). *The Health Effects of Methane and Other Associated Gases*, Cut Methane, available at: https://cutmethane.eu/learn/the-health-effects-of-methane-and-other-associated-gases/

Curry, A. (2017). *Grenfell Tower, Predictable Surprises and Slow Violence*, The Next Wave Futures, available at: https://thenextwavefutures.wordpress.com/2017/06/19/grenfell-tower-predictable-surprises-and-slow-violence/

EPA. (2022). *Climate Change and the Health of Indigenous Populations*, United States Environmental Protection Agency, December 13th, available at: https://www.epa.gov/climateimpacts/climate-change-and-health-indigenous-populations

EPA. (2023). *Ground-Level Ozone Basics*, United States Environmental Protection Agency, June 2nd, available at: https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics

ESA. (2023). *Sentinel-5P TROPOMI User Guide*, European Space Agency, available at: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-5p-tropomi

European Climate and Health Observatory, ECHO, Climate Adapt. (2023). G*round-Level Ozone Effects on Human Health Under the Changing Climate*, available at: https://climate-adapt.eea.europa.eu/en/observatory/evidence/health-effects/ground-level-ozone

Iowa Department of Natural Resources, IDNR. (2023). *Effects of Ground Level Ozone*, Environmental Protection, available at: https://www.iowadnr.gov/Environmental-Protection/Air-Quality/Air-Pollutants/Effects-Ozone

Lan, X., Thoning, K., Dlugokencky, E. (June, 2023). *Trends in Atmospheric Methane, Global CH4 Monthly Means*, Global Monitoring Laboratory, Earth System Research Laboratories, available at: https://gml.noaa.gov/ccgg/trends_ch4/

Markelova, K. (2022). *Sergey Zimov: "Thawing Permafrost is a Direct Threat to the Climate"*, The UNESCO Courier, available at: https://en.unesco.org/courier/2022-1/sergey-zimov-thawing-permafrost-direct-threat-climate

MCAF, Moms' Clean Air Force. (2023). *Indigenous People and Air Pollution in the US*, National Tribal Air Association, available at: https://www.momscleanairforce.org/resources/indigenous-people-and-air-pollution/

NASA. (2023). *Tropospheric Monitoring Instrument (TROPOMI)*, NASA Earth Data Open Access for Open Science, available at: https://www.earthdata.nasa.gov/sensors/tropomi

NASA, Earth Observatory. (2022). *Why Methane Surged in 2020*, available at: https://earthobservatory.nasa.gov/images/150967/why-methane-surged-in-2020

Nunavut Climate Change Secretariat. (2023). *Climate Change Impacts*, available at: https://www.climatechangenunavut.ca/en/understanding-climate-change/climate-change-impact

Pultarova, T. (2022). *Satellites Reveal Record High Methane Concentrations Despite Reduction Pledges*, Space.com, available at: https://www.space.com/climate-change-methane-high-despite-reduction-pledges

State of Global Air. (2019). *Health Impacts of Ozone - Ozone Exposure Accounts for 1 out of Every 9 Deaths from COPD Globally*, available at: https://www.stateofglobalair.org/health/ozone

United States Environmental Protection Agency. (2022). *Importance of Methane*, Global Methane Initiative, June 9th, 2022, available at: https://www.epa.gov/gmi/importance-methane

UN Department of Economic and Social Affairs Indigenous Peoples, UN DESAIP. (2023). *Climate Change*, available at: https://www.un.org/development/desa/indigenouspeoples/climate-change.html

UN DESASI, Department of Economic and Social Affairs Social Inclusion. (2023). *Challenges and Opportunities for Indigenous Peoples' Sustainability*, April 23rd, available at: https://www.un.org/development/desa/dspd/2021/04/indigenous-peoples-sustainability/

UNEP, United Nations Environmental Programme. (2021). *Methane Emissions are Driving Climate Change. Here's How to Reduce Them.* August 20th, available at: https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them

UNESCO. (1997). *Declaration on the Responsibilities of the Present Generations Towards Future Generations*, UNESCO, Social and Human Sciences, available at: https://en.unesco.org/about-us/legal-affairs/declaration-responsibilities-present-generations-towards-future-generations

Williams, J. (July, 2019). *Climate Change is Slow Violence*, The Earthbound Report, available at: https://earthbound.report/2019/07/23/climate-change-is-slow-violence/

WWF Arctic Programme. (2023). *Is Climate Change Threatening the Saami Wawy of Life?* WWF Arctic Programme, available at: https://www.arcticwwf.org/the-circle/stories/is-climate-change-threatening-the-saami-way-of-life/