

**THE IMPACT OF PARTICULATE MATTERS EMISSIONS:
A SOUTH KOREA STUDY**

***O IMPACTO DAS EMISSÕES DE MATERIAL PARTICULADO:
UM ESTUDO DA COREIA DO SUL***

***EL IMPACTO DE LAS EMISIONES DE MATERIAL PARTICULADO:
UN ESTUDIO DA COREIA DO SUL***

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ABSTRACT

Air pollution is currently a major global concern due to increased industrialization and its consequences for the environment. The Asian continent in particular has become one of the main affected by this type of pollution and its impacts, with many countries like China and South Korea seeking to reduce the causes of this problem. South Korea is a country particularly affected by particles, especially during changing seasons. In the article, the origins of these emissions and impacts on South Korean society were discussed, such as social habits and behaviors. The mitigation practices developed by the country to tackle this problem have shown positive results, but they are still insufficient.

Keywords: South Korea; Particulate Material; Air pollution.

RESUMO

A poluição do ar é atualmente uma grande preocupação global devido ao aumento da industrialização e suas consequências para o meio ambiente. O continente asiático em particular tornou-se um dos principais afetados por este tipo de poluição e seus impactos, com muitos países como China e Coreia do Sul buscando reduzir as causas desse problema. A Coreia do Sul é um país particularmente afetado por partículas, especialmente durante a mudança das estações. No artigo, foram discutidas as origens dessas emissões e impactos na sociedade sul-coreana, como hábitos e comportamentos sociais. As práticas de mitigação desenvolvidas pelo país para fazer face a este problema têm apresentado resultados positivos mas ainda insuficientes.

Palavras-chave: Coreia do Sul; Material Particulado; Poluição do ar.

RESUMEN

La contaminación (polución) del aire es actualmente una gran preocupación mundial debido al aumento de la industrialización y sus consecuencias para el medio ambiente. El continente asiático en particular se ha convertido en uno de los principales afectados por este tipo de contaminación y sus impactos, con muchos países como China y Corea do Sul buscando reducir las causas de este problema. Corea do Sul es un país particularmente afectado por partículas, especialmente durante los cambios de estación. En el artículo, se discutieron los orígenes de estas emisiones y los impactos en la sociedad surcoreana, como los hábitos y comportamientos sociales. Las prácticas de mitigación desarrolladas por el país para abordar este problema han mostrado resultados positivos, pero aún son insuficientes.

Palabras Clave: Coreia do Sul; Material particulado; Polución del aire.

1 INTRODUCTION

Air pollution is one of the main global concerns due to increase in industrialization and its consequences for the environment, the well being of citizens, in addition to the impact on the climate and the development of countries. In 2015, a resolution was defined by the World Health Assembly followed by a 4-year Road Map for Enhanced Global Action with the objective of implementing actions that would reduce the health impacts of exposure to air pollution at national, regional and global levels, and thus serve as a guide to policy interventions and changes (WHO, 2018a).

Reducing air pollution is essential for achieving the goals set out in the United Nations Agenda 2030, such as SDG 3 which aims for good health and well-being for all, SDG 11 (Sustainable Cities and Communities) which specifies the need for air quality in cities in their targets, SDG 12 (Responsible Consumption and Production) and SDG 13 which deals with combating climate change. As highlighted by WHO, when applying measures to minimize air pollution, all other SDGs can be reached directly or indirectly (WHO, 2016).

Currently, approximately 91% of the world's population lives in places with poor air quality, which exceeds the recommendations established by WHO of $10\mu\text{g} / \text{m}^3$. According to WHO (2020a), air pollution is responsible for approximately 4 million deaths per year due to diseases such as stroke, heart disease, lung cancer and chronic respiratory diseases. Only in the Asian and Pacific's region, 92% of the population is exposed to high levels of air pollution (UNEP, 2019).

South Korea is a country particularly affected by fine dust, especially during the changing seasons when clouds of dust are brought in from neighboring countries, and are intensified by the large number of industries operating in the country's cities. As it is a subject of great concern, the South Korean government works with air quality monitoring systems, and all data collected is reported in real time to the population through websites and apps developed for practical use on smartphones (SON et al., 2018).

The aim of this paper is to explore the impacts of particulate matter emissions in South Korea and how the country deals with this situation. In the first section, different concepts are explained for better understanding of the topic analysed. In the following section, the origin of the fine dust situation in South Korea and the impacts caused on South Korean society are presented, such as its habits and social behaviors. In the last section, the mitigation practices developed by the country to deal with this problem and whether they have shown positive results are discussed.

2 METHODOLOGY

In the present study, a literature review of the most relevant articles in the databases, such as Science Direct, Scopus and Scholar Google, was carried out. In addition to the articles, reports from specialized entities on the topic were analyzed to understand the impacts of the fine dust issue and whether the measures implemented had any positive results in combating atmospheric pollution in the country.

3 THEORETICAL REFERENCE

Brunekreef and Holgate (2002) point out that although air pollution has been a topic of discussion since the 1970s, its effects on human health have been ignored. Subsequently, the topic gained prominence worldwide because although the level of air pollution caused by the combustion of traditional fossil fuels has reduced, other components have emerged and proved to be even more harmful to human health, causing even a reduction in people's life expectancy.

Currently the most studied pollutants are ozone, particulates and nitrogen dioxide, Brunekreef and Holgate (2002) state that indoor pollution as well as outdoor pollution also has a great effect on the concentration of these gases and particles and aggravate the situation by combining its effects.

Chowdhury et al. (2012) explains that in South Asia, many rural areas use mud stoves, which are responsible for issuing " fine fractions of PM due to incomplete fuel combustion". The great global competition between countries and the constant

increase of the population in certain regions make it a challenge to improve this dynamic, since countries are under constant pressure to produce more and quickly.

Air pollution is one of the only environmental problems directly associated with the incidence of diseases such as cardiovascular diseases and cancer, as well as respiratory problems. The exposure to particulate matters has proven to be one of the biggest causes of these diseases (JUNAID et al., 2018; WHO, 2016).

In 2005, WHO released Air Quality Guidelines where it determined levels of concentration that countries should aim for daily and annually. According to the studies carried out, the exposure to high concentrations of small particulates (PM10 and PM2.5) contributes enormously to the increase in mortality or morbidity in the short and long term, so it makes them one of the most harmful to health. Despite giving specific goals, the organization stresses that the ideal is to reduce the level of these concentrations to a minimum (WHO, 2018b).

Yim et al. (2020) analyzed local emissions and transboundary air pollution (TAP) sources in Japan and South Korea, because the East Asia region is one of the most polluted regions in the world (WHO, 2020a). The result of their study showed that approximately 30% of the annual average ambient PM2.5 concentrations in Japan and South Korea in 2010 were contributed to by local emissions within each country, while 70% were TAP and originated in neighboring countries, China being one of the countries most responsible for PM2.5 concentrations.

These worrying numbers are a source of great criticism by the local population and show that efforts are required not only nationally but also partnerships between countries so that pollution in the region and its impacts are mitigated.

In addition to concerns about the effects of air pollution on the environment and human physical health, Lu (2020) emphasizes the major negative impact on people's mental health. This is because its presence affects social behaviors and interactions, people's willingness to work - fossil fuel PM2.5 pollution was responsible for 1.8 billion days of work absence- and also brings great economic losses (MYLLYVIRTA, 2020).

According to the report released by Greenpeace Southeast Asia and the Center for Research on Energy and Clean Air (2020) it is estimated that air pollution has a \$ 2.9 trillion economic cost, equating to 3,3% of the world's GDP. In China alone, the total annual cost of air pollution is estimated to be \$ 900 billion each year.

Although the numbers are concerning, it is estimated that without the current mitigation measures adopted by countries in the region, " exposure to harmful particulate matter would grow by more than 50% by 2030 based on projected economic growth of 80% over the same period " (UNEP, 2019).

However, the countries cannot be satisfied, since according to the UNEP report released in 2019 after a study of the Asian region, by extending the combat measures "22 per cent of the region's population could enjoy air quality within the WHO Guideline by 2030, compared to less than 8 per cent in 2015 ". Still, the number of people exposed to concentrations above the WHO established could drop by up to 80%, and many premature mortality from outdoor and premature deaths from indoor air pollution would also be avoided (UNEP, 2019).

3.1 AIR POLLUTION AND PARTICULATE MATTER

According to the World Health Organization, air pollution is defined as "contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere". It can be mentioned as examples of this kind of pollution, particulate matter (PM), carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide - which are also considered as the most worrying air pollutants (WHO, 2020b) - and yellow dust.

Within this context, it can characterize particulate matter as "the term for a mixture of solid particles and liquid droplets found in the air" that vary in "many sizes and shapes and can be made up of hundreds of different chemicals" according to the United States Environmental Protection Agency (EPA, 2020).

Due to these aspects, particulate matter can also be considered as Fine Dust or Ultra Fine Dust depending on its size. Fine Dust is the particulate matter smaller than 10

μm in diameter (PM₁₀), while Ultra Fine Dust has less than 2.5 μm in diameter (PM_{2.5}) (KANG; KIM, 2013).

Even though there is still the need for more studies, both of them have many evidence of causing harm to people through their penetration into the lung alveoli and so on at other human body systems, besides they being pollution factors. Moreover, it is also known that these particulate matters are mainly of man-made origin, while yellow dust, another kind of air pollutant, is of natural origin (KANG; KIM, 2013).

Yellow dust occurs when high winds coming from northern China and the deserts of Mongolia “kick up dense clouds of fine, dry soil particles” (Jeong, 2008) and carry them towards the east Asia countries. “These particles of dust and sand settle in Korea, and they elevate the ambient air pollution” (ALTINDAG et al., 2017).

Therefore, due to those aspects, it is defined as a Asian weather phenomenon and a transboundary environmental issue, which has been increased by industrial pollutants and the intensified desertification in China in the past years (JEONG, 2008). Furthermore, the Yellow Dust harm in human health is different from the ones caused by Fine and Ultra Fine Dust, which makes this another factor of why these particles have distinct terms, besides their origin differences (CHUNG, 2014).

4 SOUTH KOREA AND AIR POLLUTION

The concern of dust storms in Korea has been present for many years, even having a phenomenon called Asian dust events, due to the dust clouds transported from Mongolia deserts and eastern China. These dust clouds are popularly called " yellow sand " due to their yellow color, and have been highly discussed over the years for its harmful effects on population's health, because they carry particles from the heavy industry of eastern China (KWON et al., 2016).

Kim (2019) points out that in recent years, annual dust storms have combined with other air pollutants and have further aggravated the situation, and that chinese government itself recognizes that the emissions generated on its continent affect neighboring countries. In his study, Kim assessed that westerly wind increases PM₁₀

concentrations in South Korea and “the annual average effect of westerly wind on ambient PM10 is 19 percent, indicating that ambient PM10 levels increase by 9.5 $\mu\text{g} / \text{m}^3$ when the prevailing wind is out of the west based on annual average PM10 concentration (50 $\mu\text{g} / \text{m}^3$)”.

In the summer, the effect is more pronounced, reaching 30% compared to winter which reaches 21%. These numbers contest those presented by South Korea, which accuses China of being responsible for the local concentration of PM10 around approximately 26 to 44.5%. Emissions of pollutants into the air have also grown in line with the industrialization of Asian countries over the years. China, as one of the countries that most presented economic development, is responsible for a large part of these emissions (KIM, 2019).

In 2013, a strong haze in eastern China transported a large concentration of dust to Korea and was responsible for a major drop in air quality according to the monitoring of satellites and systems. This haze was repeated in 2004 and the problem of air pollution became the focus of study from then on in the country (KIM et al., 2016).

Seoul is one of the cities with the highest concentration of people in the country, and one of the most affected due to its large industries and the circulation of people. A study by Heo et al. (2014) showed that the combustion of chemicals is an aggravating factor in the capital and directly impacts the increase in respiratory diseases and mortality in the region.

In 2017, President Moon Jae-in announced that 10 thermal power plants that generated energy through burning fossil fuel would be suspended from March through June to decrease deterioration in air quality. These plants were responsible for 19.4 percent of the pollutants discharged by the country’s 59 power plants and the president pledged to shut down all those that used fossil burning to generate energy until the end of his term (KANG, 2017).

The population's concern has already become evident and the impact on social relations and society's behaviors is felt daily, although this topic has been addressed

rarely by scholars (JUNG et al., 2019). In a survey conducted in 2014 by the Seoul Development Institute, 51.8% of interviewees believed that air pollution was the country's biggest environmental problem, while 68.3% considered the level of air pollution to be high (CHUNG, 2014).

Children and people with respiratory diseases have been one of the most impacted by the great concentration of fine dust in the country. In a study by Lee et al. (2002), he investigated the association between outdoor air pollution and asthma attacks among children under 15 years of age in Seoul. His study revealed that even at low levels of exposure to particulates matters, the risk of asthma attacks was accentuated, and visits to hospitals increased on days when concentration levels were higher (LEE et al. 2002).

South Korea has sought in recent years to expand its partnerships with agencies and neighbor countries in order to address this issue and also develop solutions and means of mitigation that have not yet been applied by local scientists. The Asian continent has since been a constant target of UN and WHO reports where the level of atmospheric particles are analyzed and the combat actions studied according to effectiveness and solution (UNEP, 2019).

5 SOCIAL IMPACTS

Air quality is a demand that has guided many conversations and demands from South Korean society in recent years. The fact that pollution is clearly visible to the eyes adds even more weight to the population's concern about the health of their families. As highlighted by assistant Park from Economic Affairs, in the first half of 2018 the keywords most searched by South Korean users on Google were " fine dust ". Basically it has become common for the population to search about air quality daily before leaving home, and the use of masks has become very common in the country because of this issue (PARK, 2019).

Other products that have become popular in the country are window screens and clothing masters. They are used to prevent dust from entering the houses and as a

way to remove it from the clothes respectively. The search for air cleaners grew too by approximately 40% in 2018 compared to the year 2014. The country's government announced that it aimed to install air cleaners in kindergarten and school as well as other public institutions (PARK, 2019).

Research shows that air pollution is a huge problem in many countries, leading to several respiratory diseases and, consequently, to behavioral adaptations. This problem has shown that simple outdoor activities, for example, need to be rethought because people will be too exposed to air pollution. Transforming open air functions into indoor activities and installing air-purification systems in the buildings is just one of the structural changes that have to be done in order to live with minimal possibilities of breathing those particles (LU, 2020).

Regarding the psychological effects, Lu (2020) points out that air pollution is associated with increased levels of anxiety, mental disorders, self-harm, and suicide. This is mainly because exposure to pollutants reaches the system so that stress levels are intensified. South Korea as a country is already commonly known for its high levels of suicide, so the precarious situation regarding air pollution ends up worsening the mental and physical health of its population (KIM et al., 2015).

Jun (2019) argues that people living in environments with a high level of air pollution end up adopting behaviors that help them to combat its effects or even avoid exposure to pollution. He points out that one of the most common actions is for the population to avoid going out on the days when pollution alerts are issued. The author adds that many people prefer indoor activities and install air-purification systems in buildings.

People's engagement with law to reduce emissions from vehicles and factories and the move to other cities to escape the areas of high concentration of Fine Dust, also became common in the daily lives of the South Korean population. These behaviors reveal the way people have found to react to the environment in which they live, in addition to the hope that they will be able to escape its negative effects.

6 MITIGATION PRACTICES

In 2008, South Korea proclaimed as a national vision the Low-carbon Green Growth with the aim “to shift the nation's growth paradigm from a fossil-fuel dependent growth paradigm to a quality-oriented growth paradigm with a focus on utilizing new and renewable energy sources and green technologies” (SHIN, 2009). With this vision, the country took as a mission to address air pollution issues as a whole, and thus reduce the impacts of all types of gases and particulate matters harmful to human health.

Within this context, in the next year, its government established the National Green Growth Strategy, “a long term blueprint for green growth through 2050, as well as the Five-Year Plan for Green Growth for annual implementation of the strategy through 2013.” (YANG, 2017). This action created ten policy agendas with the aim, among other things, to reduce the use of fossil fuels, and to the South Korean government pursue gas emissions mitigation strategies (YANG, 2017).

To enable those actions, the Framework Act on Low Carbon Green Growth was enacted in 2011. According to the Grantham Research Institute on Climate Change and the Environment, it “requires the government to establish and implement a national strategy, action plans, and a detailed 5-year plan for a planning period of 20 years, which will deal with various aspects of climate change mitigation and adaptation.” (LSE, 2020).

After the act implementation, several mitigation practices were applied in South Korea. One of these practices, that is related with the particulate matter and the first management plan focused on the Seoul region due to its poor air quality compared to other regions, was The Special Act on Seoul Metropolitan Air Quality Improvement launched in 2013 with the intention of reducing the annual concentrations of PM10 and NO₂ within 10 years (KIM, 2019).

Furthermore, other examples are the Greenhouse Gas and Energy Target Management System and the Korean Emissions Trading Scheme (KETS). The first one has the aim to reduce the industry's gas emissions, it “imposes GHG reduction and energy conservation targets on large businesses that are emitting more than 15,000 tCO₂eq,

but less than 25,000 tCO₂eq” (UNDP, 2017). While industries that emit more than 25,000 tCO₂eq are controlled by the KETS, which also made South Korea become the second asian country “to introduce a nationwide cap-and-trade system” (IETA et al. 2016) with the implementation of it.

Moreover, at the end of 2016, South Korea made another important step into the particulate matter mitigation practices when it ratified the Paris Agreement in which the country pledged “to reduce greenhouse gas emissions to 37% below the business-as-usual level by 2030” (ADB, 2018). This commitment is part of the Korean Nationally Determined Contributions (NDCs), the national declaration of the Paris Agreement that South Korea established, as well as the other Parties, each one of them with their own NDCs.

However, even with the implementation and the pledge of all the mitigation practices and other related actions previously mentioned, it is perceived that the air pollution indices have not decreased in South Korea, in fact, they got worse in the last years. According to the Brown to Green 2019 report, greenhouse gas emissions, for example, have increased more than 30% between 1990 and 2016, and fossil fuels still “make up around 81% of South Korea’s energy mix” (CLIMATE TRANSPARENCY, 2019).

Within this context, in 2019, the South Korean government created the second National Climate Change Adaptation Program with the aim “to reduce greenhouse gas emissions by 24 percent from 2017 levels by 2030” (KBS WORLD, 2019). One of the plan’s mitigation practices for example is to Seoul “cut greenhouse gas emissions from 709 million tons in 2017 to 536 million tons in 2030 by pushing for reductions in power generation, construction, transportation, agriculture and forestry” (KBS WORLD, 2019).

Furthermore, the government established a new standard crisis management manual. Under the new guide, the government now “issues alerts according to four different levels – attention, caution, alert, and serious – when high concentration of ultra fine dust is detected” (KIM; LEE, 2019).

Alongside this guide, Kim and Lee (2019) point out that other countermeasures were implemented, like the offer of health protection masks in childcare centers and other facilities, and the launch of a full-scale disaster response that mobilizes all available means and resources when alert and serious warnings are issued. One of these responses, for example, is to advise drivers to voluntarily leave vehicles with odd-number license plates at home on even-numbered dates and use public transportation more often (KIM; LEE, 2019). All these measures were established in the hope that the impacts of air pollution would be mitigated to the maximum in the country.

7 CONCLUSION

The problem of air pollution in the world, and especially in South Korea, has permeated popular discussions and moved government actions, however the situation remains critical. The effects on human physical and mental health are vast and the daily habits of the population remain affected, in addition to the impacts on the environment resulting from constant human action and accelerated industrialization.

East Asia in particular has received focus on this issue as they suffer the exponential effects of pollution from their neighboring countries, such as China. Despite the partnerships between the governments of these countries in the hope that this problem will be mitigated, the numbers still point to little evolution and much work still needs to be done.

In South Korea, there is an intensification of social impacts, such as the worsening of mental illnesses and anxiety attacks in periods of high PM 10 levels and the increase in respiratory diseases. The adaptations made by the population in their daily activities such as the preference for indoor activities or for not going out on days with high levels of pollution, leave them at the mercy of a condition that few countries suffer, despite air pollution being a global problem.

Among the measures adopted by the local government, it is clear that the approach adopted is to keep the population informed about the levels of pollution, through alerts and reports. Also, instructing the use of domestic equipment and specific

air purifiers to reduce contamination in houses. However, as this does not solve the root of the problem, the ideal would be to adopt more rigid actions, like taxing the countries responsible for the pollution that is transported, since it is the main source of pollution in the region.

Also, demand a greater response from the global community, and put themselves as actors at the forefront of the movement that advocates for the end of the use of toxic materials and increasingly promote the use of green energies. Due to the strategic size of the country, government officials should also have an interest in reducing local emissions generated as much as possible. Thanks to the extensive knowledge of South Korean universities on the subject and their technological arsenal, it is important that the country uses these factors to its advantage.

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