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INCREASING THE VISIBILITY AND KNOWLEDGE BASE ON AIR QUALITY WITH BIG DATA AND ITS IMPACT ON THE POPULATION HEALTH

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1 INTRODUCTION

Agriculture, as one of the key sectors of the world economy, plays an important role not only in ensuring food security but also in the environmental context. While its primary objective is the production of food, fibre and fuel, agricultural activity also has a significant impact on the environment, particularly on air quality. Within the global discourse on climate change and sustainability, air pollution caused by agriculture is becoming a key concern. This text provides a detailed analysis of agriculture's contribution to air pollution, identifies the main sources of pollution and focuses on the measures that are being taken to reduce this negative impact.

2 THEORETICAL BACKGROUND

2.1 Air pollution caused by agriculture

- ***Ammonia emissions (NH_3):*** Ammonia is one of the main air pollutants from agriculture, with emissions closely linked to the use of nitrogen fertilisers and livestock production. Agriculture is responsible for approximately 90% of global ammonia emissions (Sutton et al., 2011). This gas is rapidly converted in the atmosphere to secondary inorganic aerosols such as ammonium salt particles, which contribute to the formation of fine dust particles (PM2.5). These particles have significant health impacts, particularly on the respiratory and cardiovascular systems (Behera et al, 2013).

  Ammonia emissions are mainly generated from livestock where urea from their urine is broken down into ammonia (Misselbrook et al., 2016). Another major source of ammonia is nitrogen-containing mineral fertilizers, which undergo microbial processes that release ammonia into the atmosphere when applied to the soil (Bouwman et al., 1997).

- ***Methane (CH_4) emissions:*** Methane (CH_4) is a major greenhouse gas with a high global warming potential, which is approximately 28 times more effective at trapping heat in the atmosphere than carbon dioxide (CO_2) (Forster et al., 2007). Agriculture contributes to methane emissions mainly through livestock production, specifically through the digestion of ruminants such as cows, which produce methane during digestion, which is subsequently emitted to the atmosphere (Gerber et al., 2013).

  Another important source of methane is rice paddies, where anaerobic conditions in flooded soils lead to methane production by microorganisms (Neue, 1993). Manure management, especially under wet and anaerobic conditions, also contributes to significant methane emissions (Oenema et al., 2005).

- ***Nitrous oxide (N_2O) emissions:*** Nitrous oxide (N_2O) is another major greenhouse gas, with a global warming potential almost 300 times higher than CO_2 (Ravishankara et al., 2009). This gas is mainly produced by microbial processes in the soil, especially denitrification and nitrification of nitrogen

fertilizers (Mosier et al., 1998). The use of synthetic fertilizers, but also organic fertilizers such as manure and compost, significantly increases N_2O emissions (Smith & Conen, 2004).

Increased concentrations of N_2O in the atmosphere contribute not only to global warming but also to ozone depletion, which has further adverse environmental consequences (Ravishankara et al., 2009).

- ***Dust and particulate matter (PM) emissions:*** Dust and particulate matter (PM) emissions are another important aspect of air pollution associated with agricultural activities. These particles are generated during mechanical processes such as ploughing, mowing and crop handling (Funk et al., 2008). Dust particles PM10 and PM2.5 are particularly harmful because they can penetrate deep into the lungs and cause serious health problems including asthma, bronchitis and other respiratory diseases (Pope et al., 2009).

  Agricultural processes such as crop residue burning are also significant sources of PM (Andreae & Merlet, 2001). Crop burning, especially in Asia and Africa, contributes to seasonal episodes of severe air pollution and increases the risk of air pollution-related diseases (Venkataraman et al., 2006).

- ***Volatile organic compounds (VOCs) and pesticides:*** Volatile organic compounds (VOCs) are another class of pollutants that are associated with agriculture. Pesticides, which are widely used in agriculture to control pests and diseases, can release VOCs into the air during application and subsequent volatilization (Atkinson & Arey, 2003). These substances contribute to the formation of ground-level ozone, which is harmful to both human health and plants (Jenkin et al., 1997).

  VOCs from pesticides can also contribute to air pollution at both regional and global scales because they can be transported over long distances (Derwent et al., 2003). This increases the risk of exposure of humans and ecosystems to the harmful effects of these substances.

- ***Combustion of agricultural residues:*** In some regions, agricultural residues are burned, leading to the production of various pollutants, including carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx) and particulate matter (PM). This process has serious negative impacts on air quality and the health of the population. Alternative methods of treating agricultural residues, such as composting or mulching, can reduce the need for incineration and thus the production of harmful emissions.

2.2 Why agriculture is one of the biggest air polluters

Agriculture is one of the biggest air polluters for several reasons:

1. ***Extensive application of fertilizers and pesticides:*** intensive agriculture requires large amounts of fertilizers and pesticides, which contribute to emissions of ammonia and nitrogen oxides.

2. ***Livestock farming:*** Large numbers of livestock produce significant amounts of methane and ammonia.
3. ***Mechanisation and agricultural operations:*** Mechanical operations such as ploughing, mowing and harvesting release dust particles into the air.
4. In many countries, ***agricultural residues are burned***, which increases emissions of greenhouse gases and dust particles
5. ***Global expansion of agriculture:*** Increasing world population leads to expansion of agricultural production, causing further pollution.

Intensification of agriculture

The intensification of agriculture in recent decades, driven by increasing demand for food, fibre and biofuels, has led to an increase in the use of inputs such as synthetic fertilizers and pesticides (Tilman et al., 2002). These inputs, while increasing productivity, also have a negative impact on the environment, particularly on air quality. Increasing livestock intensity leads to higher methane and ammonia emissions, while intensive tillage increases dust and nitrous oxide emissions (Mosier et al., 1998).

Improper land management

Improper land management, including excessive tillage, burning of crop residues and excessive use of fertilizers, leads to deterioration of soil quality and increased emissions of pollutants (Lal, 2004). Erosion and degradation of soils release stored carbon into the atmosphere, which contributes to increasing concentrations of greenhouse gases (Pimentel, 2006).

Dependence on chemical fertilisers and pesticides

Dependence on chemical fertilizers and pesticides is another reason why agriculture is one of the biggest air polluters. Improper or excessive use of these substances leads to inefficient use of nutrients and increased emissions of harmful pollutants such as nitrous oxide and ammonia (Davidson, 2009). The volatility of pesticides contributes to the dispersal of air pollution over long distances, increasing the risk of contamination.

Measures to reduce air pollution from agriculture

Accurate agriculture

Precision agriculture, which involves the use of modern technologies such as satellites, sensors and information systems, offers opportunities to reduce pollutant emissions (Gebbers &

Adamchuk, 2010). These technologies enable the precise application of fertilizers, pesticides, and water, minimizing overuse and reducing greenhouse gas and ammonia emissions (Zhang et al., 2015). Precision agriculture also promotes more sustainable use of natural resources, which can have a positive impact on air quality.

Sustainable fertiliser and nutrient management

One of the most important measures to reduce air pollution is the use of sustainable fertilizers and better nutrient management (Snyder et al., 2009). This includes the use of organic fertilizers such as compost and manure, which can reduce nitrous oxide and ammonia emissions compared to synthetic fertilizers (Galloway et al., 2004). Improved nutrient management includes techniques such as staggered fertilizer applications that minimize nutrient losses and reduce greenhouse gas emissions.

Reducing methane emissions

There are several approaches to reducing methane emissions in livestock production. These include feed changes that can reduce methane production during digestion in ruminants, as well as improved manure management that includes techniques such as anaerobic digestion that can reduce methane emissions from manure (Hristov et al., 2013). Improvements in rice field management such as intermittent irrigation can also reduce methane production (Linquist et al., 2012).

Alternative and biological pesticides

The use of alternative and biological pesticides is another way to reduce air pollution. These pesticides typically have lower volatility and less tendency to contaminate the air compared to conventional chemical pesticides (Pimentel, 2009). Their use can reduce the formation of ground-level ozone and other harmful substances.

Soil rehabilitation and afforestation

Rehabilitation of degraded land and afforestation are other important measures that can help reduce air pollution caused by agriculture. These measures not only improve soil quality and increase its ability to sequester carbon, but also reduce erosion and dust (Lal, 2004). Afforestation can also contribute to reducing greenhouse gas emissions by sequestering CO_2 from the atmosphere (Fargione et al., 2008).

2.3 Technological innovations and improvements

- ***Urease and nitrification inhibitors:*** The use of urease and nitrification inhibitors can reduce ammonia and nitrogen oxide emissions. These substances slow down the conversion of urea and ammonia into nitrates, thereby reducing greenhouse gas emissions. Grizetti et al. (2020) point out that the use of these inhibitors in combination with other measures can significantly reduce emissions from agriculture.
- ***Improved fertiliser application techniques:*** Precision farming and improved fertiliser application techniques, such as applying fertiliser directly to the soil or using controlled-release fertilisers, can reduce the amount of emissions released. These methods minimise nitrogen losses to the atmosphere and improve fertiliser use efficiency.
- ***Alternative feeds and supplements:*** Changing feed and adding supplements that reduce methane production are effective ways to reduce emissions from livestock farming. O'Brien and D'Antonio (2021) report that some supplements, such as oils and tannins, can reduce methane production by more than 20%.
- ***Cover crops and protective strips:*** The use of cover crops and protective strips can reduce soil erosion and the release of dust particles. These measures also improve soil quality and reduce the need for chemical fertilisers.
- ***Alternative methods for treating agricultural residues:*** Instead of burning agricultural residues, methods such as composting, mulching and anaerobic digestion can be used. These methods not only reduce pollutant emissions but also produce valuable products such as compost and biogas.

2.4 Policy and regulatory measures

- ***Policies to reduce ammonia emissions:*** The European Union and other regions have adopted various policies to reduce ammonia emissions, such as regulations on fertiliser storage and application. These policies include requirements for the use of cover sheets on manure land, restrictions on fertilizer application during certain times of the year, and promotion of technologies to reduce emissions.
- ***Subsidies and financial incentives:*** Government subsidies and financial incentives encourage farmers to implement greener practices. Subsidies for the purchase of abatement technologies, such as low-emission fertiliser spreaders and biogas digesters, can make a significant contribution to reducing pollution.
- ***Education and consultancy:*** Educating farmers and providing advice on sustainable farming practices are key to the successful implementation of emission reduction measures. Awareness-raising and training programmes help farmers to understand and adopt new technologies and practices.

2.5 International initiatives and cooperation

Paris Agreement and global commitments

The Paris Agreement sets out global commitments to reduce greenhouse gas emissions, including those from agriculture. Countries are required to submit Nationally Determined Contributions (NDCs) that include measures to reduce emissions from agriculture.

UN programmes and other international organisations

Organizations such as the UN and the Food and Agriculture Organization (FAO) implement programs to promote sustainable agricultural practices. These programs include technical support, funding, and sharing of best practices among countries.

Success rate of measures

The success of measures to reduce air pollution from agriculture depends on their implementation and adaptation to local conditions. In the case of precision agriculture, it has been shown that it can reduce GHG emissions by up to 20% (Zhang et al., 2015). The use of sustainable fertilizers and better nutrient management can reduce ammonia and N_2O emissions by 30-50% (Snyder et al., 2009). Changes in manure and feed management can reduce methane emissions from agriculture by 10-30% (Gerber et al., 2013).

On the other hand, implementing these measures can be costly and difficult, especially in developing countries where technical and financial resources are lacking (Smith et al., 2007). Therefore, these measures need to be supported by adequate policies, financial incentives and farmer education to achieve widespread implementation and maximize their environmental benefits (Tilman et al., 2011).

2.6 Evaluating the success of the measures

- ***Improving air quality:*** The success of measures to reduce air pollution from agriculture is measured by improvements in air quality. Studies show that in regions where stringent regulations and abatement technologies have been implemented, ammonia, methane and particulate matter concentrations have been significantly reduced.
- ***Reductions in greenhouse gas emissions:*** Measuring GHG emissions before and after the implementation of measures is key to assessing their success. Venterea and Dijkstra (2019) highlight that the use of nitrification inhibitors and improved fertilisation techniques led to reductions in N2O emissions of up to 40%.
- ***Economic efficiency:*** The economic efficiency of measures is an important factor for their long-term sustainability. Financial analyses show that some technologies and practices, such as biogas

digesters, may have high upfront costs, but in the long term they yield savings and gains in energy production.

- ***Farmers' acceptance:*** Farmer acceptance of the measures is key to their successful implementation. Awareness raising and farmer education programmes help to increase the adoption rate of new technologies and practices. Studies show that farmers who have access to extension services and financial incentives are more willing to adopt greener practices.

3 CONCLUSION

Agriculture is a major air polluter, contributing to emissions of ammonia, methane, nitrous oxide, particulate matter and other pollutants. Intensification of agricultural production, poor soil management and dependence on chemical fertilisers and pesticides are exacerbating the problem. There are a number of technical, policy and international measures that can significantly reduce these negative impacts, including precision agriculture, sustainable fertilizers, methane emission reduction and the use of biological pesticides, the use of urease and nitrification inhibitors, improved fertilizer application techniques, alternative feeds, cover crops, composting of agricultural residues, regulation and subsidies. Evaluations of the success of these measures show that they make a significant contribution to improving air quality and reducing greenhouse gas emissions, but their success depends on the degree of farmer adoption, cost-effectiveness, adaptation to local conditions and support from policy and financial mechanisms. Continued cooperation at national and international level, as well as support for innovation and farmer education, is essential to achieve sustainable agriculture.

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