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Air pollutants and outlays vs quality of life in Poland and the welfare economics

JOLANTA PAKULSKA

Cardinal Stefan Wyszynski University in Warsaw, Faculty of Social and Economical Sciences, Institute of Economy and Finance, ul. Wóycickiego 1/3, 01-938 Warsaw, Poland
jolanta.pakulska@gmail.com
orcid.org/0000-0002-8605-2295

Abstract

Motivation: The paradigms of the welfare economics are considered to be the basis of modern considerations on the measurement of quality of life. Today, there is no doubt that the quality of the environment, and especially the air quality that man breathes, is an essential element of the quality of life. Environmental problems, including air quality, often contribute to the failure of economic policies aimed at maximizing people's well-being. Therefore, the state of all elements of the environment is important for the effectiveness of the implementation of the welfare economics and ensuring a satisfactory standard of living of the society. The last 20 years in Poland have been a time of catching up with many years of neglect in the area of the natural environment. It is a process that takes time and there is no possibility to achieve a high environmental quality of life in the short term. There is no disputing that measures were taken during this period to improve the environmental quality of life.

Aim: The study focused on air quality, as it is an element of the environment that cannot be cleaned before use. The aim of the study is to check whether the measures taken to reduce emissions of pollutants into the atmospheric air have been effective and to what extent it was possible to improve its condition and to improve the environmental quality of life of the Polish society in terms air the air we breathe.

Results: The results of the analysis in dynamic terms indicate that the quality of life in Poland during the transition, taking into account the emission of the main air pollutants, has improved.

Keywords: emissions of major air pollutants; quality of life; welfare economics
JEL: A12; I3; Q53; Q56

1. Introduction

The growing popularity of the issue of welfare and its numerous concepts have led to the creation of welfare economics. The subject of its interest is an entity that maximizes its usability (satisfaction) by satisfying its own, unchanging over time consumer preferences (Rybka, 2019, p. 208). These preferences have also been accompanied in recent decades by expectations to benefit from high environmental values. As a result, a growing group of people expect to have at their disposal the natural environment of the highest quality, that they will breathe clean air, use clean water (both for recreational and consumer purposes), and that they will be able to relax in high-quality forests. However, the natural environment that surrounds us often fails to meet these expectations, and environmental problems contribute to the failure of economic policies aimed at maximizing human well-being. It turns out that the quality of the environment is important for people's well-being and the quality of their lives, as well as for the traditional growth-oriented economy.

2. Literature review

Considerations of prosperity were already conducted in antiquity, but concepts on the meaning of this notion have evolved considerably throughout the history. In the classical economics of A. Smith, D. Ricardo and J.S. Mill, prosperity meant an increase in the amount of manufactured product. Smith (1954) believed that work, capital and skills were the determinants of the prosperity of nations.

Economists' interest in the concept of welfare has created a new trend of economics: welfare economics. Pigou (1906; 1912; 1920) is considered to be its creator, who translated prosperity theory into economic policy purposes. His two works discuss the economics of prosperity: *Wealth and welfare* (1912) and *Economics of welfare* (1920). Pigou described prosperity as the sum of the usefulness of society as a whole (Kasprzyk, 2015, p. 289). The principles of the new welfare economy were formulated in 1938 by Bergson (1938). Pigou's successors focused on the concept of usefulness and the social welfare function (H. Hotteling, A.P. Lerner, N. Kaldor (1939, pp. 549–552), J.R. Hicks, M.W. Reder, P.A. Samuelson) (Bentham, 1958, pp. 17–56; Mill, 1979).

Sen, who received the Nobel Prize in 1998, made a big contribution to the development of welfare economics. Sen noted that we differ in age, gender, physical and mental condition, body immunity, intellectual abilities or social environment, so differences in income, wealth or social status are also natural Sen (1970, 1982). However, efforts must be made to ensure the relative prosperity of as many individuals as possible. Sen has extended the understanding of prosperity beyond economic prosperity alone (Kasprzyk, 2015, p. 291). According to Sen (1982), prosperity can be understood as a person's quality of life, which consists of many elements, such as healthy eating, good health, to more complex factors, such as being happy, having the sense of dignity or participating in social life.

Today, the concept of prosperity far exceeds the economic view. We can talk about the concept of economic prosperity (welfare) and quality of life, which includes much more elements that are changing over history. Representatives of many sciences write about this concept (Aksman, 2010, p. 13; Czapiński & Panek, 2011; Zeliaś, 2004, pp. 12–20). In literature, we can also come across the concept of so-called overall public welfare (well-being), which takes into account also psychological factors affecting the overall level of satisfaction associated with the standard of living (Allardt, 1993, pp. 88–94; Kot, 2000, p. 216; Sen, 1982).

Literature on prosperity and welfare economics is very rich. There are also many studies on the environmental impact (including atmospheric air quality) on human health. However, there are no analyses indicating a link between the amount of pollutant emissions (which largely translates into environmental quality) and the quality of human life. This study contributes to further research on this issue.

3. Methods

The study uses a descriptive, statistical and analytical method. The descriptive method was based on domestic and foreign literature on the subject, which brought the issue of welfare economics, prosperity and quality of life closer to the context of the environmental quality of life and outlays on the environmental protection. Then, through the analysis of changes over time of the emission of main air pollutants, which are an important indicator of the environmental quality of life, Poland's achievements in the transition period in this area are shown. These data are derived from publicly available statistics published by the Central Statistical Office (CSO, 2001–2019) in the *Environmental protection yearbook* (since the CSO began the publication of all needed for this analyses environmental data, that is, since the 2000). These data are also comparable throughout the period of availability, which gives the possibility of analysis over a relatively long period of time. The results of the studies are presented in the graphic layout.

4. Welfare economics, prosperity and quality of life

Welfare economics is an integral part of the classic school of economics. In theory, it defines the criteria for social choice and, at practical level, applies those criteria to assess economies based on different institutions (government, market) in order to identify the most desirable choice. Proponents of welfare economics believe that in the market economy, state interference is necessary in order to shape the division relations in such a way that each individual can achieve an adequate share of prosperity (Encyklopedia PWN, 2020).

The main area of interest in the welfare economics is, above all, the way the economy is organized. Today, it is considered the basis of the state's socio-economic policy as it improves the efficiency of resource allocation in order to maximize social well-being (Rybka, 2019, pp. 208–209). The normative nature of the welfare economics amounts to assessing the efficiency of resource allocation and fairness of the distribution of goods between economic operators. According to the welfare economics, efficient resource allocation exists when it ensures social well-being. It is worth noting that prosperity is influenced both by economic variables, which directly affect prosperity, as well as non-economic factors that have indirect impact on it through their influence on, among others, politics or culture. The concept of social efficiency or optimality is fundamental to the welfare economics, as this is the main objective of this discipline (Jutlah, 2001, p. 6; Łopatka, 2015, p. 44).

In the theory of economics, prosperity growth equates to an increase in the volume of goods produced in the economy. It assumes that all changes in prosperity should be included in the cost-benefit account of economic projects. There is currently no doubt that changes to the natural environment should also be included in this calculation. In practice, however, environmental impacts are often ignored or underestimated, as these changes are relatively difficult to measure (Pearce, 2002, pp. 57–81).

The concept of quality of life is a broader concept than the level of wealth of society and the state and economic prosperity. Prosperity is not only due to GDP growth, but above all to qualitative changes. The quality of life can be interpreted as objectively calculated on the basis of statistical data material and intangible standard of living together with a subjective assessment of life satisfaction (Polak, 2016, p. 67). Quality of life consists of a number of factors, including environmental factors (air, water pollution, forest resources, etc.) as well as factors on which the environment has a major impact (health, climate, natural and recreational conditions). The natural environment, whose resources are the basis of economic activity, as well as the quality of this environment, is now an undeniable determinant of the quality of life of modern man.

5. Influence of air pollution on human health

Air pollution is the main cause of the environmental risks, thereby having a negative impact on both the quality of the environment and on the health and quality of life of people. Emissions of pollutants into the air affect a very large area as they move without much restrictions most often over long distances (CSO, 2017, p. 48). Due to its impact on human health, air quality is one of the most important environmental constituents of quality of life. Air is a specific element of the environment, because it cannot be cleaned before we breathe.

The emissions of major pollutants such as carbon monoxide, sulphur dioxide, nitrogen oxides, ammonia and non-methane organic compounds and dusts have a major impact on the quality of air.

Atmospheric air is the medium that transmits substances contained in it to the human body, including substances that are harmful to humans. On average, a person inhales about 9 kg of air per day, therefore air pollution, even in small concentrations, can cause serious negative consequences for human health. When inhaled, impurities are absorbed directly into the bloodstream by the lungs, and the degree of harmfulness of the inhaled substances depends on the type of acting agent, as well as its concentration. Some diseases (e.g. respiratory, circulatory, cancer and other lung diseases or allergies) are closely related to the effects of polluted atmospheric air. According to OECD data, more than 3.5 million people die every year from air pollution worldwide, and in Poland 45–50 thousand people die, which is associated with the direct effects of pollution on human health (Pankowska & Gorczyca, 2015, pp. 60–61).

The negative impact of atmospheric pollution on human health is twofold (Pakulska & Rutkowska, 2002, p. 14):

- deterioration of health and well-being during periods of sudden increase in air pollution concentrations that last for several or more days, is expressed by an increase in the number of chronic diseases and an increase in deaths;
- slow deterioration of health of people affected by it over a long period of time.

In case of acute ailments, the effect of impurities is more pronounced and easier to record. This is not the case with a long-term impact, which is much more dangerous for human health. Constant presence in polluted air negatively affects all human systems. As a result of the long-term exposure to low doses of pollutants, the risk of developing such typical diseases as asthma (suffered by 3–5% of the population, and the number of patients is constantly increasing), bronchitis (about 10% of overall mortality is associated with chronic bronchitis) and emphysema. Studies also show that there is a clear correlation between air pollution and diseases and mortality for bronchitis. In polluted areas, there is also a higher proportion of lung cancer (which, however, is somewhat disturbed by smoking) (Gładka & Zatoński, 2016, p. 579).

Diseases of the cardiovascular system, which are particularly sensitive to harmful stimuli, are also the result of air pollution. Pollution causes, among others, the reduction of the amount of red blood cells in the blood (anaemia) or the increase of their amount (polyglobulia), delay in the development of bone tissue, as well as diseases of eyes and ears (Pakulska & Rutkowska, 2002, p. 15).

The gas that is emitted in the largest amount into Polish air is the main greenhouse gas, i.e. carbon dioxide (CO2). It is a natural component of air and a product of breathing. Its emissions from anthropogenic sources are the responsibility of fuel combustion processes, energy, the chemical and metallurgical industry and automotive transport. At high concentrations, carbon dioxide can cause shortness of breath, pain and dizziness, as well as reduced psychomotor performance of a person. High concentration causes heart rate and breathing acceleration, reduced physical and mental fitness (Gładka & Zatoński, 2016, p. 574).

Carbon monoxide (CO) is formed by incomplete combustion of products containing hydrocarbons. It is harmful even at a low concentration, as it causes hypoxia of internal organs (Gładka & Zatoński, 2016, p. 574; Kostrz & Satora, 2017, pp. 93–94). Therefore, even relatively small carbon monoxide emissions can cause disorders of the heart and circulatory system, as a result of which headaches or shortness of breath may occur. Excessive concentration of carbon monoxide negatively affects reproductive tissue in male humans as it disrupts the spermatozoa formation process and reduces their motility. Carbon monoxide also has a direct effect on the cells of the heart muscle (Pakulska & Rutkowska, 2002, p. 18).

Sulphur dioxide (SO2) is formed by the combustion of fossil fuels containing sulfur in combined heat and power plants, heating plants, industrial plants, local boiler rooms and individual heating boilers. It is among the most dangerous atmospheric air pollution, and its high concentration can lead to the damage to the respiratory tract. It can also cause irritation to the skin, respiratory tract, vocal cords, conjunctivals and skin. Sulfur dioxide causes vasodilation of mucous membranes, hyperemia and swelling. It is also the cause of emphysema and respiratory failure, causes cardiac impairment and damages internal organs. Reacting with steam or drops of water in the clouds creates sulphuric acid, and with dust it forms sulphates. Sulphuric acid leads to metal corrosion and causes major economic losses. Sulphur compounds (together with CO2 and NOx) are the main components of London-type smog (which is formed in winter due to lack of air mass movement and high humidity, along with high concentrations of sulphur dioxide, carbon dioxide and dusts). This smog contributes to the development of lung, cardiovascular and allergy diseases (Gładka & Zatoński, 2016, p. 574; Kostrz &. Satora, 2017, p. 93; Pakulska & Rutkowska, 2002, p. 15).

Nitrogen oxides have a negative impact on the human respiratory system. They can cause coughing, sneezing, tearing of the eyes and a feeling of shortness of breath, as well as toxic pulmonary edema, and are also the cause of the development of cirrhosis of the lungs. Nitrogen oxides are a factor causing the formation of secondary pollutants (e.g. tropospherical ozone or nitric acid) which are more harmful to human health and the environment than primary pollutants. Nitrogen oxide (NO) is mainly formed from road transport (diesel engines) and energy. It is rapidly oxidized to nitrogen dioxide (NO2), which is also formed by the combustion of organic substances containing nitrogen, detonation of explosives, electrochemical treatment of metals and the work of diesel engines. This gas at high concentrations is highly toxic and causes, among others, respiratory irritation and greater susceptibility to respiratory infections, exacerbation of asthma symptoms and conjunctivitis irritation (Gładka & Zatoński, 2016, pp. 574–757; Kostrz & Satora, 2017, p. 92; Pakulska & Rutkowska, 2002, p. 16).

A major threat to human health and thus to the quality of human life is tropospheric ozone, which is secondary pollution resulting from photochemical reactions in the air polluted with nitrogen oxides, carbon monoxide, methane and non-metallic volatile organic compounds. High concentrations of tropospheric ozone entail many risks to humans, among others, eye irritation, increased sensitivity to infections, decreased lung performance, worsening of asthma or other diseases and can also lead to premature mortality. According to the European Environment Agency, ozone air pollution led to 1,150 premature deaths in Poland in 2013 (CSO, 2017, pp. 48–49).

The impact of dusts largely depends on their chemical composition, as dusts are a carrier of many hazardous substances. Other substances may settle on their surfaces, e.g. polycyclic aromatic hydrocarbons and heavy metals that penetrate the body together with inhaled air and affect human health, as well as plants or animals. Dust particles can combine with various chemicals such as sulphur, aromatic hydrocarbons, heavy metals, dioxins and allergens. For emissions of dusts into the atmosphere are primarily responsible the combustion processes of fuels outside the industry (mainly the municipal and domestic sectors), and to a lesser extent road transport. The source of emissions is also industry (especially energy, chemical, mining and metallurgical), but these sources have less impact on the quality of life of people due to their most common location outside the built-up areas (CSO, 2017, pp. 50–51). Emitted dusts hinder the supply of solar energy, degrade the soil, and in humans cause pneumoconiosis, asthma, allergic diseases, eye diseases, inflammation of the upper respiratory tract, tumors of the throat, larynx and lungs. The dust is very lightweight, so it can fly in the air and penetrate into the alveoli, and from there even get into the bloodstream. Dusts can cause irritation and inflammation of conjunctivitis and mucosa of the nose and throat. The most dangerous is particulate matter of several microns as it penetrates deep into the lungs, reaching the alveolia and interacting with it in an irritating or toxic way (Kostrz & Satora, 2017, p. 91; Malec & Borowski, 2016, pp. 16–17). Particulate matter particles come from primary emissions (dust emissions) as well as reaction with substances in the atmosphere (secondary dust). Secondary dust is primarily the result of emissions of sulphur dioxide, nitrogen oxides, non-methane organic compounds and ammonia. Exceeding the standards for particulate matter in Poland, especially during the winter period, greatly reduces the quality of life of the population mainly from the central areas of big cities. According to estimates by the European Environment Agency in Poland, in 2013, exposure to PM2,5 dust accounted for almost 50,000 premature deaths (CSO, 2017, pp. 50–51).

6. Results

The last 20 years in Poland have been a period of decreasing emissions of major air pollutants. Only in the case of carbon dioxide we observe large fluctuations in emissions (see Chart 1), and the emission in 2017 is higher than in 2000, with the lowest emission recorded in 2002. However, the differences between individual years are not significant (the difference between the highest emission in 2017 and the lowest in 2002 is only about 9%). Thus, it can be assumed that the carbon dioxide emissions remain at a similar level. The largest part of this gas emission comes from energy production processes and more than 11% is absorbed by forest areas. A similar situation occurs in the case of emissions of non-methane volatile organic compounds (see Chart 2), but these emissions are much lower than those of carbon dioxide. The emission of these compounds remains at a similar level to slight fluctuations in individual years.

Emissions of the remaining main air pollutants have been decreasing over the last years. Emissions of nitrogen oxides (see Chart 2) decreased in the initial years, increased in 2006 and then started to decrease slightly until 2009. In 2010 emissions increased again and remained at a similar level in 2011. Between 2012 and 2016, we see another decrease in emissions, and another slight increase in 2017. Over the entire test period, nitrogen oxide emissions decreased over 14% (see Chart 2). The emission of these gases is relatively small, so such a reduction is significant. The situation is similar with regard to ammonia emissions (reduction over 14%). In 2006, the emission (see Chart 2) decreased slightly and remained at a similar level to 2014. From 2015 to 2017, emissions are again growing slightly, not reaching the level of 2000. Agriculture is by far the most responsible for ammonia emissions (in 2017 almost 85% of emissions came from agriculture). Due to the fact that this source is largely dispersed, it does not have such a significant impact on the quality of life.

A systematic decrease in emissions over the entire test period is observed in the case of sulphur dioxide (see Chart 1), which resulted in an almost 70% decrease in emissions. In the case of sulphur dioxide emissions, there is no definite “culprit” of emissions. Combustion processes in the energy production and transformation sector are in the first place (more than 40% in 2017), followed by combustion processes outside industry (almost 30%) and combustion processes in industry (almost 24%).

Similarly, a systematic decrease is recorded for carbon monoxide (see Chart 1), but here, in individual years, we observe increases in emissions, which ultimately results in a decrease of over 35%). The processes of combustion outside the industry are largely responsible for these emissions (in 2017 almost 60%). Thanks to actions aimed at greening these processes, by changing the type of fuel burned or replacing the furnaces, it has been possible to achieve a large reduction in emissions and improve the quality of life.

Particulates emissions (see Chart 4) in 2017 compared to 2000 also decreased significantly (over 70%). In the initial period, emissions increased slightly, but then (except for 2010) they decreased systematically. Almost a half (more than 47%) of the particulates emissions in 2017 were caused by combustion processes outside the industry, while the remaining sources are at most slightly more than 10% of the emissions.

Searching for the causes of the decrease in emissions of the main air pollutants, it is worthwhile to look at the amount of expenditure on fixed assets used to protect the air and climate (see Chart 3). The size of these expenditures since 2000 is characterized by quite high variability. From 2000 to 2005, the expenditures have been systematically falling. The trend has been reversed since 2006 (probably due to larger investments financed from EU funds in connection with Poland's accession to the EU since 1 May 2004). Until 2010, this growth was systematic but slow. In 2011, the outlays increased by leaps and bounds, and a similar increase can be observed again in 2015 and 2016. It should be assumed that this is related to the EU programming periods and decisions concerning the financing of Polish projects for the protection of air and climate. The curve of capacity of the equipment commissioned to operate in the field of gaseous pollution reduction is similar.

The variability in the ability of the commissioned equipment to reduce particulate pollutants contamination is slightly different (see Chart 4). In this case, only in some years, a convergence between the amount of inputs and the ability to reduce particulates pollution can be seen, which is difficult to explain and requires further analysis. In the case of particulates pollution, the increase in the ability to reduce particulates pollution of commissioned equipment to reduce this emission is also not visible. Although this emission is gradually decreasing, the capacity of the equipment to reduce the emitted dusts is much less than increasing. It can only be justified by the fact that the amount of generated particulates pollutants increases faster than the reduction capacity, which is certainly not a positive phenomenon.

7. Conclusion

An important area of interest for the welfare economics is prosperity, the understanding of which has changed throughout history. Nowadays, its important determinant is the quality of life, the components of which are also changing. Nowadays, the condition of the natural environment, in which modern man lives, is to a large extent a determining factor for the quality of life. One of its elements is the atmospheric air, which every man must use and which he cannot "cleanse" before use.

The analysis showed that over the last 20 years, progress has been achieved in the case of most of the pollutants emitted into the atmosphere, which was mainly due to an increase in the amount of ecological investments. Thus, it can be concluded that thanks to this, the environmental quality of life in the field of atmospheric air of Polish inhabitants has improved.

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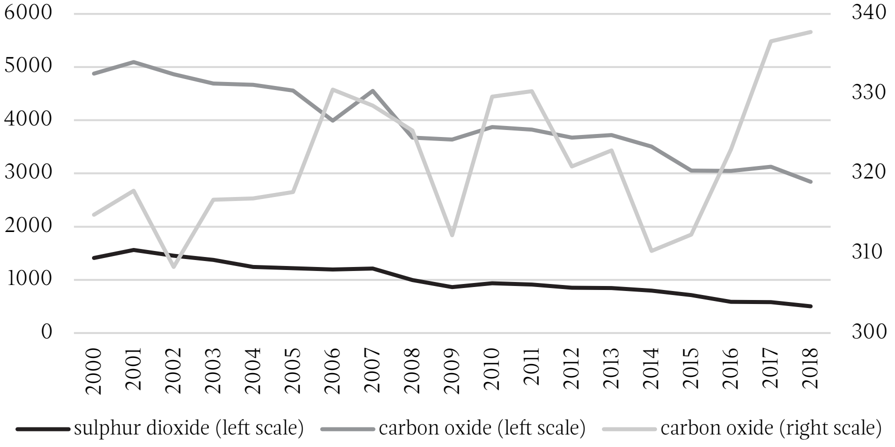
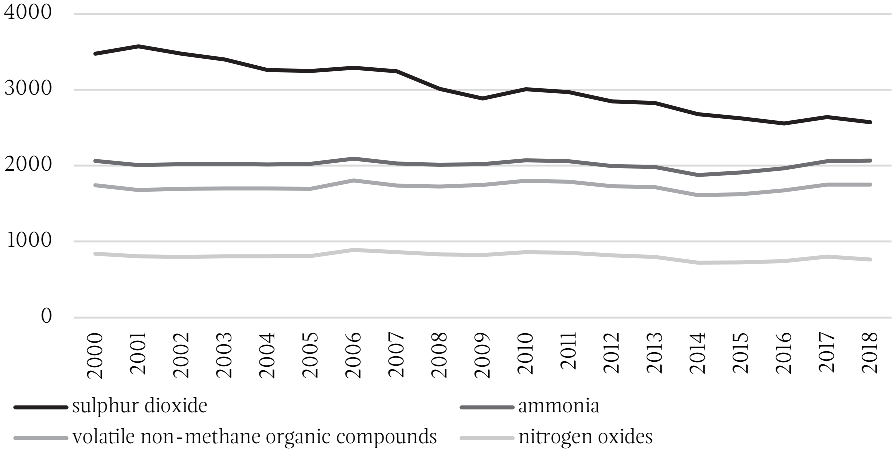
Appendix

Chart 1.
Total emission of sulphur dioxide, carbon oxide (in thousands tonnes) and carbon dioxide (in million tonnes) in 2000–2018



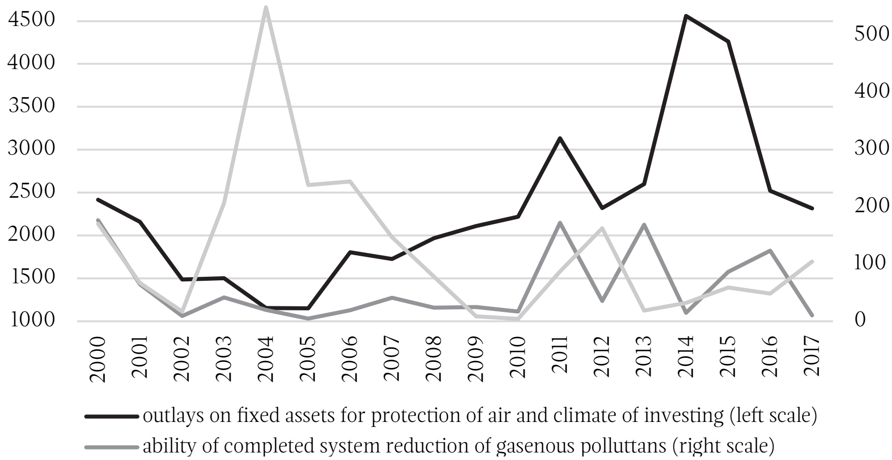
Source: Own preparation based on CSO (2001–2019).

Chart 2.
Total emission of nitrogen oxides, volatile non-methane organic compounds and ammonia in 2000–2018 (in thousands tonnes)



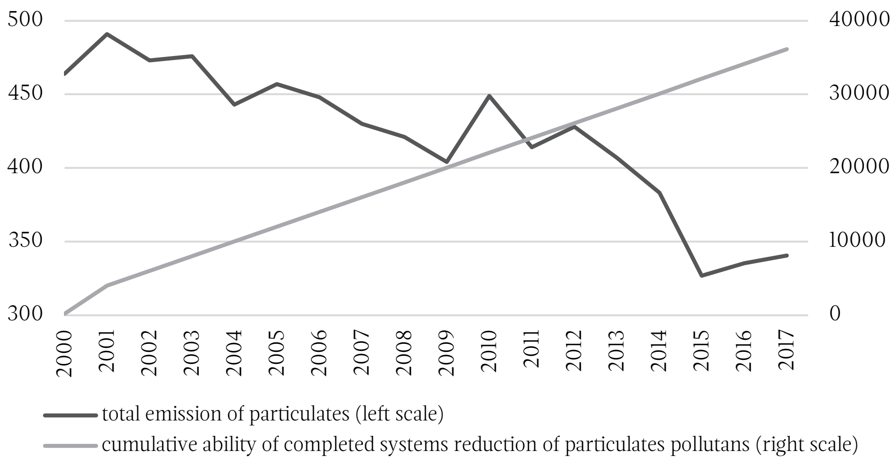
Source: Own preparation based on CSO (2001–2019).

Chart 3.
Outlays on fixed assets for environmental protection of investing (curren prices, in mln PLN) and ability of completed systems reduction of particulates pollutans and gaseuos pollutans (in thousands t/y) in 2000–2017



Source: Own preparation based on CSO (2001–2019).

Chart 4.
Cumulative ability of completed systems reduction of particulates pollutans in 2000–2017 (in thousands t/y)



Source: Own preparation based on CSO (2001–2019).