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EMISSIONS OF MAJOR AIR POLLUTANTS AS AN INDICATOR OF QUALITY OF LIFE IN POLAND IN 1990-2017

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ABSTRACT: In recent deliberations on the quality of life, the air quality that man breathes plays a significant role. It is beyond dispute that since 1990, Poland has been a period of making up for many years of neglect of the natural environment. The study aimed to check whether the measures taken to reduce pollutants' emissions into the atmosphere were effective and to what extent it was possible to improve its condition and improve the environmental quality of life of Polish society in this area. The index of emission of the main air pollutants was used (this group includes: sulphur dioxide, nitrogen oxide, carbon oxide and dioxide, non-metallic volatile organic compounds, ammonia and particulates) to achieve the assumed objective. Using the statistical data available in the yearbooks Environment, an analysis of these compounds' emissions was carried out. The study used the descriptive, statistical and analytical method. The analysis showed that over the period analysed, emissions of the main air pollutants had decreased significantly in most cases, which has undoubtedly contributed to improving the environmental quality of life.

KEYWORDS: emissions of major air pollutants; quality of life, welfare economics

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Introduction

Quality of life most often refers to the objectives and effects of economic development. The paradigms of welfare economics, around which non-economic sciences are also developing, have become the basis for considering the measurement of quality of life, where other aspects complement the concept of prosperity in economic sense, e.g. the development of the economy, social security, political or civic conditions, family and the quality of the environment (Szyguła, 2017, p. 8-9).

Understanding the concept of welfare has been transformed throughout history, as until the mid-20th century, prosperity was treated as a purely sociological category. In the second half of the 20th century, it was also considered an economic category, but welfare was only limited to recent economic measures. Today, however, prosperity is a much broader category, as many indicators define its level. Therefore, welfare is measured not only in economic terms because it depends not only on the assets held or on the level of consumption per capita (these indicators define only well-being) (Krabbe, 1989, p. 46). Measuring prosperity is much more complicated, as it is economical and philosophical and psychological or political. Therefore, the measurement should take into account economic, social and ecological aspects. Due to its multi-aspect nature and a wide range of elements that should be taken into account in formulating a single, coherent measure of prosperity, it is not surprising that such an indicator has not yet been created.

Well-being can be understood as the extent to which a person feels satisfied with life, while in the theory of economics, the growth of prosperity is tantamount to an increase in consumption. There is no doubt that economic conditions and cultural, political and environmental conditions are important factors when the level of well-being is regarded. Although prosperity is very often associated with consumption, but in the light of current trends, instead of using consumption to assess prosperity, economists estimate human “prosperity” in all its complexity. Today, increasing emphasis and the analysis of prosperity are being placed on sustainable development and the state of the natural environment (Gowdy, 2005, p. 216-217).

Sustainability can be considered economically irrational, which is contrary to the objectives of welfare economics, as caring for prosperity for future generations leads to a reduction in the availability of natural resources, which will contribute to the reduced current production of goods and a reduction in the well-being of the current generation. Lower production will mean fewer goods available on the market, which will not lead to an increase in prosperity in the classical sense. Furthermore, reducing these goods over the long term will lead to uneven distribution over the long term, which means a lack of market demand and supply balance. On the other hand, it is known that the market mechanism is unreliable and that overproduction of goods is a frequent market phenomenon. This means that supply exceeds market demand. The constraints introduced for a rational management of natural resources could likely lead to increased producer costs and, consequently, a supply reduction. If the changes were sufficient, they could lead to the equalisation of demand and supply, which would mean a market balance. By studying sustainable development from the point of view of the welfare economics assumptions, it is possible to check how the natural environment affects consumer satisfaction with the consumption of goods (both public and private) (Osiecka-Brzeska, 2011, p. 23-24).

The concept of quality of life is a broader concept than economic prosperity due to GDP growth and qualitative changes. On the one hand, quality of life is an objectively calculated standard of living based on statistical data. On the other hand, it is a complex measure influenced by many environmental factors (e.g. air pollution) and factors that are highly influenced by the environment (e.g. health).

A suitable quality of life can be ensured with an appropriate economic standard, but this is insufficient to recognise and assess life quality as high. Without a doubt, good health is a factor without which the quality of life is not satisfactory. The quality of the natural environment, especially atmospheric air, has a significant impact on human health. Its proper quality is a condition of human health (well-being and access to clean air and the absence of diseases).

An overview of the literature

The concept of quality of life can already be found in ancient thinkers who identified quality of life with happiness. Hippocrates saw happiness in the inner balance of man. On the other hand, Aristotle considered the pursuit of the highest possible achievable good as a guarantee of happiness, with economic prosperity as the only means to achieve happiness. They sought an answer to what happiness is and what can ensure a high quality of life for the man (Trzebiatowski, 2011, p. 26; Kot, 2004, p. 107). Throughout the centuries, many attempts have been made to determine what quality of life is. In the literature of the subject, life quality is defined as satisfaction with the level of satisfaction of the diverse needs of the individual or collective life, related to safety, health, work, living conditions or surrounding social and natural environment (Pielesiak, 2017, p. 52).

In recent years, the science of quality of life has been developing very rapidly (Diener, Lucas and Oishi, 2002); there are many definitions of quality of life, well-being, which stem from various theoretical assumptions. The theory of comparison is worth mentioning here (Michalos, 1985), Kahneman's concept of objective welfare (Kahneman, 2012), theories embedded in philosophical currents (Seligman, 2004) or emphasising the almost one hundred percent share of genetic determinants in the formation of a sense of happiness (Lykken, 2000). Among Polish researchers, Janusz Czapiński proposing the so-called "onion concept of happiness", stands out (Czapiński, 2001).

According to Gillingham and Reece: "quality of life is the degree of satisfaction obtained by an individual as a result of consuming goods and services, spending free time, and enjoying the remaining material and social conditions of the environment in which that individual is located (Gillingham, Reece, 1980). Allardt differentiates between the concepts of the standard of living and quality of life, linking standard of living to material needs and quality of life to non-material needs (Allardt, 1993). Bentham stresses that the proper aim of action for the general public is to make as many people as possible happy as possible. The relative value of different actions should be measured using a 'pleasure calculus' (felicific calculus). It is supposed to be a reference system for rulers, and the main determinant is the "pleasure and suffering" experienced by society as a consequence of the actions taken.

Considering the development of research on the quality of life, one cannot fail to mention the American psychologist Angus Campbell, who emphasised that without reference to the sense of satisfaction, it is impossible to answer the question about the quality of life of an individual. He believes that life quality includes the degree of satisfaction from family life, work, neighbourly relations, social relations, health, ways of spending free time, education, profession or general standards influencing the quality of life within the local community. (Campbell, 1981).

The quality of life is also being considered by economists, who have been looking for years to distinguish between the quality of life and welfare. Sen, who received the Nobel Prize in 1998 for his reflections on well-being economics, made a significant contribution to this work. Sen noted that we differ in terms of age, gender, physical and mental condition, body resilience, intellectual capacity or social environment, so it is also natural to have differences in income, wealth or social status (Sen, 1970). However, the aim must be to ensure the relative well-being of as many individuals as possible. Sen has extended the understanding of prosperity beyond economic prosperity alone. According to Sen, prosperity can be understood as a person's quality of life, which consists of many elements, such as eating, good health, to more complex factors, such as being happy, feeling dignified or participating in society (Sen, 1982). He also stated that neither ancient philosophy nor medieval Christian thought combined the ideal of happiness with economic prosperity.

In the Polish literature, we can find analyses of changes in the emission of pollutants in Poland over the years. For example, Nowicki writes about environmental protection progress in recent years (Nowicki, 2014). There are also many studies on the environmental impact (including atmospheric air quality) on human health. However, no analyses are 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.

Research methods

The study uses a descriptive, statistical and analytical method. Thanks to the descriptive method, the concept of life quality was discussed based on the literature on the subject, especially in environmental quality. A dynamic analysis of the emission of main air pollutants in Poland over the last 30 years was made using statistical data concerning the emission of main air pollutants. The main air pollutants are sulphur dioxide, nitrogen oxide, carbon oxide and dioxide, non-metallic volatile organic compounds, ammonia and particulates. The choice of these data was determined by their availability in such a long time. These data come from statistics published by the Central Statistical Office in the yearbooks Environment (since the Central Statistical Office started publishing environmental data on a systematic basis, i.e. since the 1990s).

In most cases, these data are also comparable over the entire availability period, making it possible to analyse them over a relatively long time. Thanks to this, Poland's achievements in this area have been demonstrated. The results of the research are presented in a graphic layout.

Results of the research

Emissions of major air pollutants in Poland have significantly decreased over the last 30 years (see figures 1 and 2). The lowest percentage of decreased emissions was recorded for carbon dioxide (less than 12% – see table 1). Fluctuations in the emissions of this gas are being observed throughout the analysis period, as emissions are increasing over specific periods, resulting in a relatively small decrease in emissions as a whole. The most significant proportion of these gas emissions come from energy generation processes (in 2017, almost 94% – see table 2). A positive phenomenon is that more than 11% of the carbon dioxide emitted is absorbed by forest areas (see figure 3). Thus, in addition to changing the structure of energy sources towards sources emitting less carbon dioxide, the second direction of reducing the threat to quality of life on the part of this gas is to increase the surface of forest areas that will more absorb harmful emissions.

Similarly, there is a small decrease in emissions of non-methane volatile organic compounds (less than 16% – see table 1). Their emissions decreased by 2015 (in 1990-2015, the decrease was almost 20%), and in the last two years, it has been steadily increasing. Most of these emissions come from anthropogenic sources (more than 70%), but emissions from these sources have also decreased by a larger degree (almost 17%). In this case, there is no strong leader in the share of emissions (see table 2).

Emissions decreased by around 40% were recorded for nitrogen oxides (more than 37%) and ammonia (approximately 44%) – see table 1. The emissions of these gases are relatively small, so such a reduction is significant. For ammonia, emissions increased in some years but overall decreased significantly (see figure 2). Similarly, as nitrogen oxide emissions are concerned,

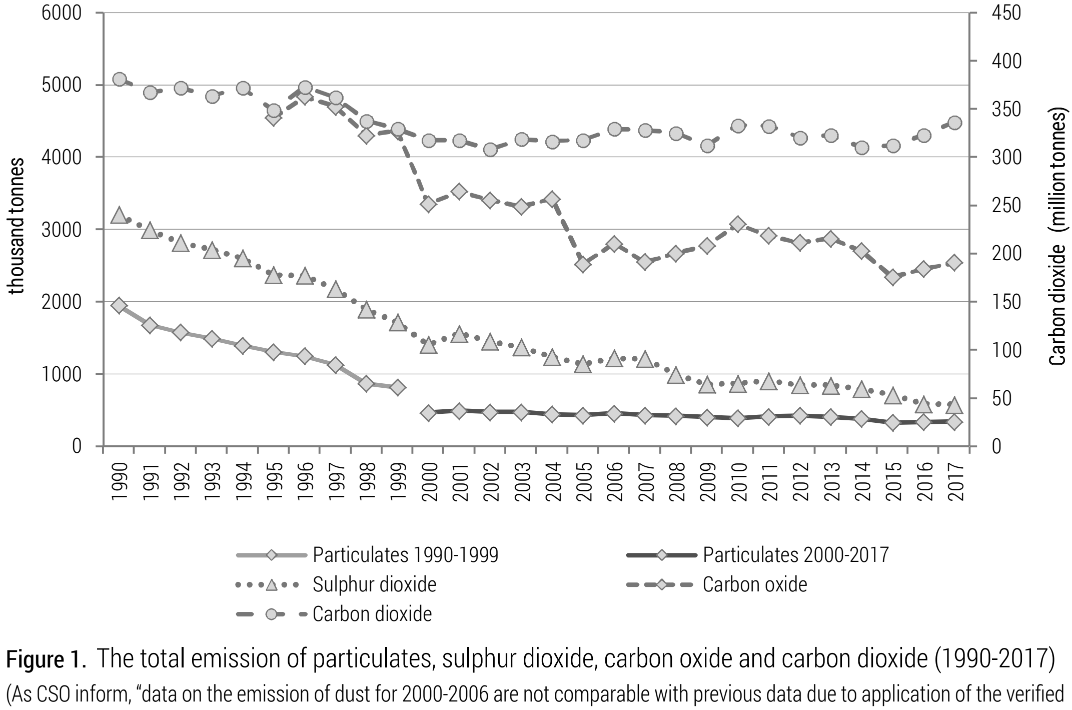

Figure 1. The total emission of particulates, sulphur dioxide, carbon oxide and carbon dioxide (1990-2017)

(As CSO inform, "data on the emission of dust for 2000-2006 are not comparable with previous data due to application of the verified methodology of their estimation: some categories of emission sources were added, and new emission indicators were applied. Calculated volumes of total dust emission for 2000-2006 are much lower than the level of dust emission estimated in former stock-takings because the volume of emission was exceeded – especially for the category "combustion processes in the industry" and "production processes" especially in the second half of the 90's – mainly owing to not taking into account the upgrade of equipment and technological progress.")

Source: author's work based on GUS, 2001-2019.

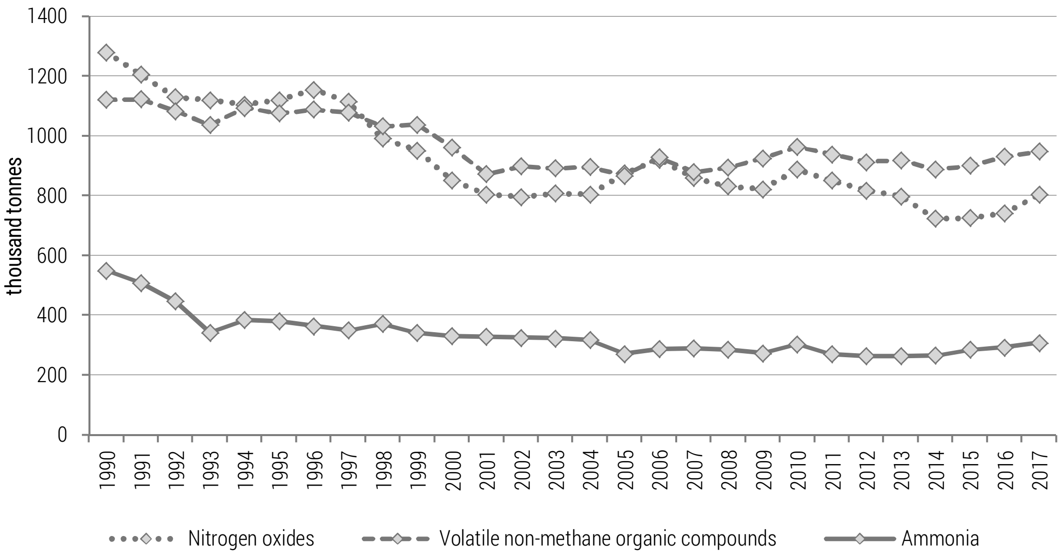

Figure 2. The total emission of nitrogen oxides, volatile non-methane organic compounds and ammonia (1990-2017)

Source: author's work based on GUS, 2001-2019.

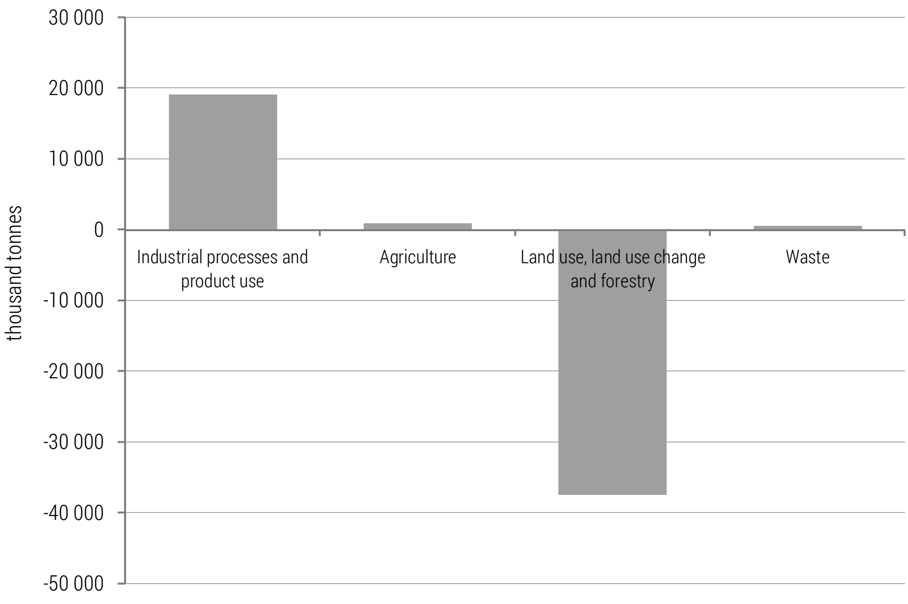

Figure 3. The total emission of carbon dioxide by emission sources in 2017

Source: author's work based on GUS, 2019.

a small increase in emission was observed in 2005 and 2010, but ammonia emissions decreased significantly during the period considered (see figure 2). Car transport is the most responsible for emissions of nitrogen oxides. During the research period, the number of motor vehicles moving on our roads has significantly increased. However, these are increasingly modern vehicles, thanks to which the global emissions of this gas have been reduced. Agriculture is the most responsible for ammonia emissions (almost 85% of agricultural emissions in 2017 – see table 2). Thanks to the fact that this source is largely dispersed, this does not significantly impact the quality of life.

A similar reduction has been achieved in carbon oxide emissions since 1995 (around 44% – see table 1), especially since 1999 (see figure 1). This emission is largely the result of combustion processes outside the industry (in 2017, almost 60% – see table 2). Thanks to measures aimed at greening these processes, by changing the type of fuel burned or replacing furnaces, a large reduction in emissions and improved quality of life has been achieved.

Very significant emission reductions have been achieved in sulphur dioxide (almost 82% – see table 1). In the case of sulphur dioxide, an even reduction in emissions is recorded throughout the research period. There is a lack of a strong "culprit" of emissions (see table 2). Combustion processes in the energy production and transformation sector ranked first (in 2017 more than 40%), the next places are occupied by combustion processes outside the industry (almost 30%) and industrial combustion processes (almost 24%). The decrease in sulfur dioxide emissions from mobile sources since 2004 results from a significant decrease in the sulfur content in liquid fuels of this category. Combustion processes outside the industry caused almost half (more than 47%) emissions in 2017; the remaining sources were up to just over 10% of emissions (see table 2). The decrease in sulphur dioxide emissions is due, as in carbon monoxide emissions, to the measures taken to reduce emissions from these sources.

In the case of particulates emissions due to a change in methodology by GUS, comparisons should be made in two periods: 1990-1990 and after 2000. In the first period, the decrease in emissions reached over 41% (see table 1), while in the second period it remained at a similar level.

Table 1. Emission indices of the main air pollutants (1990-2017)

Specification	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Sulphur dioxide	100.00	93.30	87.85	84.89	81.15	74.02	73.77	67.94	59.10	53.55	43.95	48.72	45.36
Nitrogen oxides	100.00	94.14	88.28	87.50	86.33	87.50	90.16	87.11	77.42	74.30	66.55	62.89	62.19
Carbon dioxide	100.00	96.38	97.60	95.41	97.59	91.47	97.83	94.97	88.63	86.44	83.41	83.32	80.81
Carbon oxide	no data	no data	no data	no data	no data	100.00	106.38	103.36	94.61	96.00	73.80	77.59	74.99
Volatile non-methane organic compounds	100.00	100.18	96.61	92.51	97.59	95.99	97.15	96.25	92.06	92.60	85.87	77.88	80.11
Ammonia	100.00	92.36	81.27	62.18	69.8	69.09	66.18	63.64	67.45	62.00	60.13	59.64	59.09
Particulates 1990-1999	100.00	86.15	81.03	76.67	71.5	67.08	64.10	57.95	44.67	41.7	no data	no data	no data
Particulates 2000-2017	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	100.00	105.82	101.94

Specification	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sulphur dioxide	42.83	38.66	36.50	38.07	37.88	31.12	26.85	27.25	28.35	26.57	26.39	24.92	22.18	18.40	18.15
Nitrogen oxides	63.13	62.81	67.93	71.95	67.19	64.92	64.22	69.37	66.48	63.83	62.34	56.48	56.66	57.98	62.79
Carbon dioxide	83.64	83.02	84.55	86.40	86.11	85.29	81.85	87.41	87.18	84.11	84.64	81.34	81.87	84.68	88.22
Carbon oxide	72.97	75.35	67.94	61.67	56.15	58.81	61.10	67.68	64.13	61.97	63.25	59.47	51.52	54.02	55.93
Volatile non-methane organic compounds	79.57	79.93	85.81	82.87	78.41	79.75	82.60	85.90	83.68	81.45	81.98	79.21	80.30	83.00	84.55
Ammonia	58.73	57.64	58.97	52.18	52.55	51.82	49.64	55.15	49.09	47.82	47.82	48.18	51.77	53.08	55.91
Particulates 1990-1990	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data	no data
Particulates 2000-2017	102.59	95.47	87.52	98.71	92.67	90.73	87.07	84.00	89.22	92.24	87.72	82.54	70.45	72.24	73.41

Source: author's work based on GUS, 2001-2019.

Table 2. The total emission of main air pollutants by kinds of activity in 2017

	Sulphur dioxide		Nitrogen oxides		Carbon oxide		Volatile nonmethane organic compounds		Ammonia		Particulates	
	in thousand tonnes	in %	in thousand tonnes	in %	in thousand tonnes	in %	in thousand tonnes	in %	in thousand tonnes	in %	in thousand tonnes	in %
Combustion in energy production and transformation industries	251.30	43.13	168.90	22.78	51.19	2.01	2.55	0.27	-	-	14.91	4.60
Non-industrial combustion plants	170.87	29.33	85.72	11.56	1505.80	59.11	116.15	12.35	7.76	6.08	152.05	46.96
Combustion in industry	138.85	23.83	73.35	9.89	212.83	8.35	41.27	4.39	3.68	2.88	34.07	10.52
Production processes	18.82	3.23	25.59	3.45	68.23	2.68	66.17	7.03	1.35	1.06	34.69	10.71
Extraction and distribution of fossil fuels	1.94	0.33	1.36	0.18	0.30	0.01	50.52	5.37	-	-	12.88	3.98
Solvent and other product use	-	-	-	-	-	-	206.96	22.00	0.02	0.01	-	-
Road transport	0.55	0.09	297.36	40.11	588.44	23.10	85.43	9.08	4.74	3.71	24.06	7.43
Other vehicles and machinery	0.18	0.03	84.71	11.43	96.26	3.78	9.56	1.02	0.02	0.01	11.46	3.54
Waste management	0.14	0.02	2.21	0.30	19.66	0.77	10.48	1.11	2.04	1.60	5.22	1.61
Agriculture	0.00	0.00	2.19	0.30	0.54	0.02	94.67	10.06	108.10	84.65	34.25	10.58
Other sources of pollutant emission and absorption	-	-	0.02	0.00	4.33	0.17	257.03	27.32	-	-	0.18	0.06
Total	582.66	100.00	741.42	100.00	2547.58	100.00	940.80	100.00	127.70	100.00	323.77	100.00

Source: author's work based on GUS, 2019.

Conclusions

The analysis indicated that during the last 30 years, there was a significant improvement in Poland's quality of life in terms of atmospheric air quality. On the one hand, it seems that air and climate protection investments have helped reduce emissions. On the other hand, this has been influenced by structural changes in the economy. A thorough analysis of the reasons for reducing emissions requires further analytical work.

It is clear that it is not emissions that are decisive, but air pollution immissions; however, it is the volume of emissions that has the most significant impact on the immissions. Considering the need to carry out a long-term analysis covering the beginnings of environmental statistics in Poland, it was not possible to make comparisons on the immission of air pollutants. Therefore, it was necessary to analyse the volumes that most affect the immission, that is, the air quality that Poland's inhabitants breathe.

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