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Air pollution in Türkiye depending on environmental pressure categories

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Abstract. The aim of this paper to analyse the air pollution in Turkey depending on four environmental pressure categories, namely global warming potential, acidification potential, tropospheric ozone-forming potential and particulate formation potential for the period 1990-2018. The individual air pollutant effect for each environmental pressure group has been examined and discussed. According to the air pollution analysis, global warming potential, acidification potential and particulate formation potential effects are in an upward trend while tropospheric ozone-forming potential effect is in a downward trend for the time period 1990-2018. And the environmental pressure category where the highest increase is realized in all environmental pressure categories is the global warming potential category. This paper provides information on the causes of air pollution and offers policy recommendations for reducing air pollution in Turkey.

1 Introduction

One of the most important problems facing the nations of the world is environmental pollution. Various regional and global environmental problems arise as a result of air pollutant emissions into the atmosphere.

Some individual air pollutant emissions can cause several types of environmental and health effects. Therefore, air pollutants are classified according to their environmental and health effects. Air pollutants such as carbon monoxide (CO), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), nitrogen oxides (NOx), particulate matter (PM_{10}), sulphur dioxide (SO_2), carbon dioxide (CO_2) and methane (CH_4) are classified into environmental pressure categories: global warming potential (GP), acidification potential (AP), tropospheric ozone formation potential (TP) and particle formation potential (PP). This classification is presented in Table 1 [1-3].

The air pollutants are aggregated into the environmental pressure categories by using conversion factors. The air pollutant conversion factors for each environmental pressure category are given in Table 2 [4]. As seen in Table 2, an air pollutant that has a low impact on any environmental pressure group may have a greater impact on another environmental pressure group. In other words, having a low impact within a certain environmental pressure group does not mean that it will have a low impact on other environmental pressure groups [5-6].

Several studies have been studied to find out the environmental performance for some countries [7-9]. Some of those studies are related to investigating individual air pollutant emissions effects [10-11]. These studies deal with the international inequality of environmental pressures and economic growth versus environmental pressure in various countries for selected time periods. Some of those are concentrated on measuring environmental sustainability performance environmental sustainability for several countries [12-13].

The environmental and health effects of individual air pollutants may show different effects in different environmental pressure categories. For this reason, it would be a more accurate approach to evaluate the environmental and health effects of individual air pollutants within environmental pressure categories in a holistic structure.

On the other hand, the public and policy makers are ultimately interested in the totality of environmental problems, not individual air pollutants.

The aim of this study is to analyse air pollution in Turkey by considering the individual air pollutant impact for each environmental pressure group based on four environmental pressure categories, namely GP, AP, TP and PP for the period 1990-2018.

2 Material and Methods

GP, AP, TP, and PP categories are constructed by using the individual air pollutants given in Table 1. The effects of the individual air pollutants have been inserted into the related environmental pressure category by using the conversion factors given in Table 2.

National data for (CO_2, CH_4) and (CO, NH_3, NMVOC, NO_x, PM_{10}, SO_2) emissions for the study

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period are obtained from the European Environmental Agency Greenhouse Gas Data Viewer [14] and the European Environmental Agency Air pollutant emissions data viewer [15] respectively. Due to the lack of SO_2 emissions data in the database, SO_x emissions data were used instead of SO_2.

The constructed environmental pressure categories have been analysed in the following subsections.

Table 1. Combination of air pollutants into the environmental pressure categories.

Pollutant	Environmental Pressure (Units)
CO_2, CH_4	GP (Tons of CO_2-eq.)
SO_2, NO_x, NH_3	AP (Tons of AP-eq.)
CO, NO_x, NMVOC, CH_4	TP (Tons of TP-eq.)
NO_x, SO_2, NH_3, PM_{10}	PP (Tons of PP-eq.)

Table 2. Air pollutants conversion factors.

Pollutant	Environmental pressure	Conversion factors	Units
CO_2 CH_4	GP	1 21	Tons of CO_2-eq.
SO_2 NO_x NH_3	AP	0.03125 0.02174 0.05882	Tons of AP-eq.
CO NO_x NMVOC CH_4	TP	0.11000 1.22000 1.00000 0.01400	Tons of TP-eq.
NO_x SO_2 NH_3 PM_{10}	PP	0.88000 0.54000 0.64000 1.00000	Tons of PP-eq.

2.1 Global Warming Potential Changes

The total carbon dioxide (CO_2) emissions of all greenhouse gases in Turkey in 1990, 220 million tons of CO_2-eq. while this value was increased to 405 and 533 million tons of CO_2-eq. in 2010 and 2018 respectively [14].

The change in the GP trend is upward. And the most important effect comes from the CO_2 emission in this category. CO_2 emission effect on the GP category was increased from 69% to 81% between 1990 and 2018. Although the CH_4 emission effect in this category was not as much as CO_2, it was increased by 35% from 1990 to 2018 (see Figure 1).

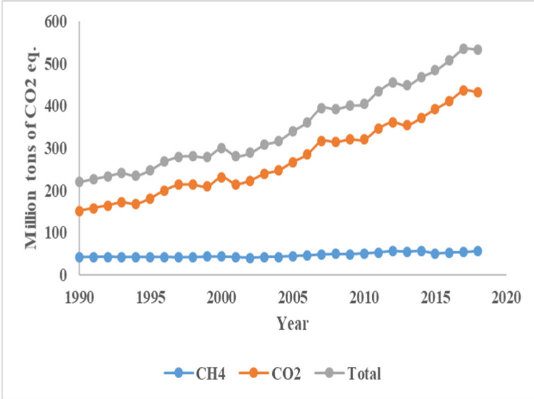

Fig. 1. The change in GP of Turkey

2.2 Acidification Potential Changes

As seen from Figure 2 [15], the change in AP of Turkey, which was 94600 tons of AP eq. in 1990 while this value was increased to 154720 tons of AP-eq. in 2018. The change in the AP trend is upward. And the most important effect comes from the air pollutants SO_x and NH_3 respectively in this pressure category.

SO_x and NH_3 emission effects on the AP category were approximately at the same level for the years 1990 and 2018. Those emission effects were 52% and 38% for SO_x and NH_3 respectively in 2018. Although NO_x emission effects in this category were not as much as SO_x and NH_3 emission effect. There was a fluctuation in NO_x emissions in this pressure category for the study period (see Figure 2).

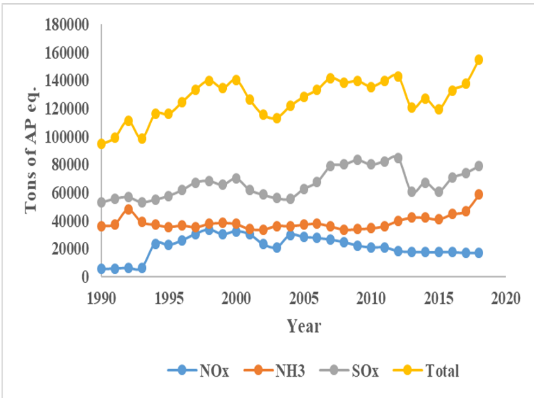

Fig. 2. The change in AP of Turkey

2.3 Tropospheric Ozone Forming Potential Changes

The change in TP of Turkey, in 1990, 1459100 tons of TP-eq. while this value was increased to 2261300 tons of TP-eq. in 2018. The maximum value occurred in 2000 within a value of 4417100 tons of TP-eq [15]. The change in the TP trend is downward (See Figure 3). And the most important effect comes from the air pollutants NMVOC and NO_x respectively.

In the TP category, the most important addition comes from NMVOC and NO_x respectively. NMVOC and NO_x emission effects in the TP category were 48%

and 42% respectively in 2018. The addition of CH_4 and CO emission effects on the TP category was quite smaller than NMVOC and NO_x emission in 2018. The percentages were 2% for CH_4 and 8% for NMVOC for this year (see Figure 3).

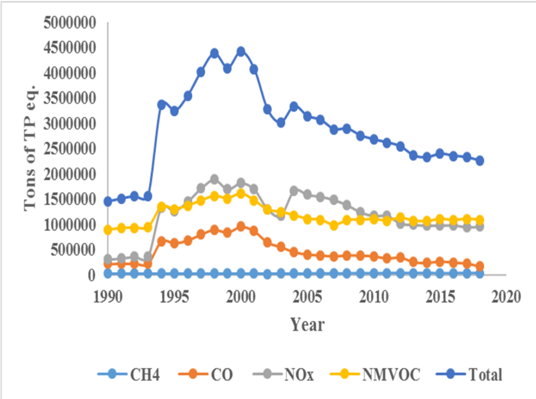

Fig. 3. The change in TP of Turkey

2.4 Particulate Formation Potential Changes

As seen from Figure 4 [15], the change in PP of Turkey, which was 1810000 tonnes of PP-eq. in 1990 reached 2932700 tons of AP-eq. in 2018. The maximum value occurred in 1998 within a value of 3294700 tons of PP-eq. The change in the PP trend was shown fluctuations in the study period. In 2018, the most important effect came from the air pollutants SO_x, NO_x, and NH_3 respectively in this pressure category. The additions of SOx, NOx, and NH3 to the PP category were 46%, 24%, and 22% respectively. The least addition to the PP category comes from PM_{10} emissions within %8 (see Figure 4).

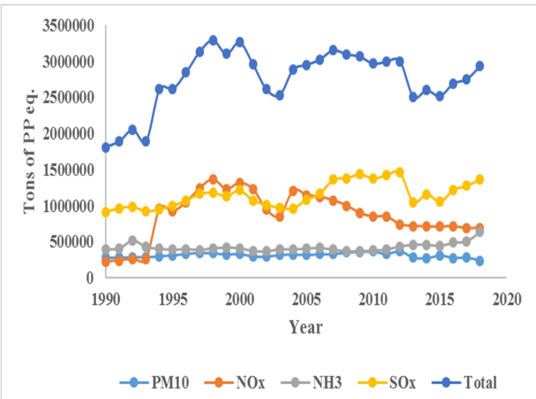

Fig. 4. The change in PP of Turkey

There are no studies from other countries where individual air pollutants are evaluated in environmental pressure categories as in this study. For this reason, CO_2, SO_x and NO_x emissions, which have the highest percentages in environmental pressure categories, are compared with Romania and Bulgaria, which are members of the European Union and whose gross national product [16] in 2018 is close to Turkey. The changes in these emissions in Turkey, Romania and Bulgaria in the 2000-2018-time period are presented in Table 3 [14, 15].

Table 3. Emission changes in 2000-2018 time period (%)

Country	CO_2	SO_x	NO_x
Türkiye	86	248	-24
Romania	-17	-86	-30
Bulgaria	-5	-93	-42

As can be seen from Table 3, Turkey has not been able to reduce these emissions as much as the other two countries in the 2000-2018-time period.

3 Discussions

GP, AP, and PP have increased within the study period while TP decreased. It has seen that the most important increase was in GP when the environmental categories were compared (See Figures1-4).

For air pollutants CO_2, SO_x and NO_x, which have high emission values in environmental pressure categories, emissions of these air pollutants should be reduced in order to reduce their impact in the environmental pressure categories in which they are located. The sectoral distribution of CO_2, SO_x and NO_x emissions for the study period are presented Figures 5-7.

As seen from Fig.5, mainly energy supply (ES) and following it industrial processes and product use (IPPU) was responsible for CO_2 emissions.

As seen from Fig.6, energy supply (ES), manufacturing and extractive industry (MEI) and residential, commercial & institutional (RCI) sectors were caused by SO_x emissions (See Figure 6).

NO_x emissions have come from energy supply (ES), manufacturing and extractive industry (MEI), and transport (T) sectors (see Fig.7).

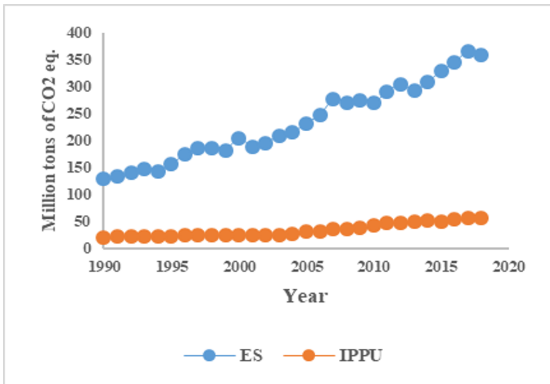

Fig. 5. The sectoral distribution of CO_2 emissions

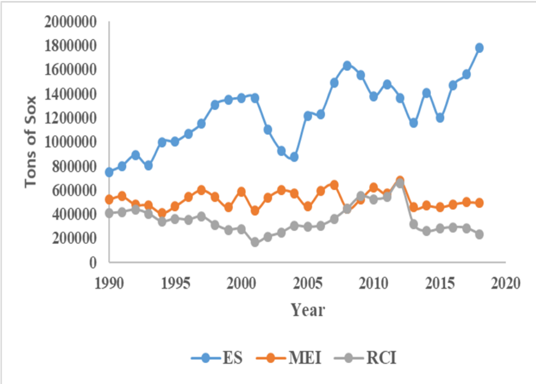

Fig. 6. The sectoral distribution of SO_x emissions.

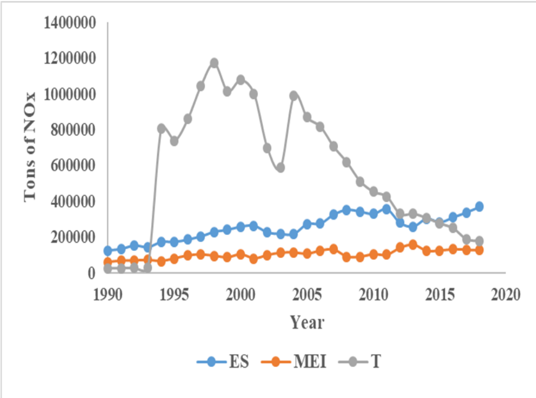

Fig.7. The sectoral distribution of NO_x emissions.

The main reason for these emissions is the use of fossil resources in the energy and transportation sectors. Reducing these emissions will be possible by reducing fossil fuel consumption in these sectors. For this, there is a need for economic regulation, decentralization in energy and de-monopolization, especially in electricity generation.

Technology optimists believe that innovations are the key to producing more with less input. Progress would be enough to dissociate economic growth and its effects on the environment [17]. In contrast, according to technology pessimists, technology alone won't be enough to overcome all the problems in a much more dynamic and crowded world [18]. Therefore, countries in the future will have to develop without economic growth: "stationary state". No matter which opinion is embraced, it has to be accepted that GDP can't be a measurement of economies' health and prosperity.

In addition to these approaches, for a livable environment on a global and local scale, economic degrowth would be a more correct approach than stationary state in economic development.

Energy cooperatives make a significant contribution to producing electricity where it is consumed, decentralizing electricity generation, reducing environmental pressures and energy dependency. Supporting the rapidly developing energy cooperatives will also prevent monopolies in electricity generation.
Energy cooperatives are a very new sector in Turkey. Citizens' interest in cooperatives is growing, and examples of practices that support energy cooperatives are among the promising developments for the future of the sector.
The main barriers to the development of energy cooperatives in Turkey include restrictions on local production of renewable energy, difficult access to finance, and lack of sufficient number of members.
Energy cooperatives are a challenging and multidimensional field of endeavor all over the world. Energy markets are dominated by large capitalized companies. Existing regulations often favor these companies. Pioneering energy cooperative organizations have a major responsibility to convince politicians and the public that cooperatives are a viable option for energy.

Turkey should radically implement climate action planning that includes mitigation measures for net zero emission targets [19,20].

In the future, sectoral impact on emissions can be investigated [21,22] and also the time period of the study could be extended to cover the pandemic period to investigate the pandemic effect on emissions [23].

4 Conclusions

The air pollution in Turkey depending on four environmental pressure categories, namely GP, AP, TP, and PP for the time period 1990-2018 has been analysed. GP, AP, TP, and PP categories have important global and regional environmental and health effects. By considering these effects of GP, AP, TP, and PP based on the analysis some policies can be suggested for Turkey:

•Undoubtedly, the country's energy and industrial policies need to be addressed in the context of environmental problems to improve environmental performance. However, to become the singular purpose of economic growth in Turkey's development process does not only put pressure on the environment but also limit the environmental problems handling requests and adequacy direction. For this reason, first of all, a redefinition is required in the developmental understanding that sees the natural environment as an asset that can be sacrificed for economic growth.

•Undoubtedly, the demands of the public in this direction are important to achieve this change. But a significant number of citizens in the country believe that Turkey's problems will be solved by economic growth. In the case of increasing the level of knowledge regarding the environment's effects on daily life, it can be expected that the quality of economic growth, which is a highly controversial topic in economics, to enter the agenda of the public. Therefore, a healthy, sustainable growth that doesn't ignore the environmental and social costs should be sought. While this aim is hard to achieve, it isn't impossible to do so.

•In power plants, an independent authority should periodically check air pollutant emission measurements to ensure audit impartiality. And the measured results should be made available to local people on a regular basis.

•The principle of minimizing negative effects on the environment should be taken into account in all industrial and residential, commercial & institutional investments. Research and development in the area of minimizing the pollutant emissions from industrial investments should be supported and funded by the government.

•Legislation to support electricity generation based on renewable resources needs to be revised within the framework of an approach that aims to base Turkey's energy policies on domestic, new and renewable resources.

References

1. Houghton J.T., Meiro Filho L.G., Callander B.A., Harris N., Kattenburg A., Maskell K. *Contribution of Working Group I to the 2nd Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press (Cambridge, 1996)
2. M. Kortelainen, Ecological Economics **64,** 4 (2008)
3. A.Ç.Köne, T. Büke, Ecological Indicator **45**, 1 (2014)
4. European Environment Agency, Individual Pollutants and Environmental Pressure Categories, www.eea.europa.eu/data-and-maps/data/eea.../fileCached (10 April 2018)
5. R. Turconi, A. Boldrin, T. Astrup, Renewable and Sustainable Energy Reviews **28**, 1 (2013)
6. A.T.Y. Quek, A. Ee, A. Ng, T.Y. Wah, Energy Policy **122,** 1 (2018)
7. Y. Yu, D. Chen, B. Zhu, S. Hu, Ecological Indicators **24,** 1 (2013)
8. T. Büke, A.Ç. Köne, Sustainability **8,** 1 (2016)
9. J. Kabayo, P. Marques, R. Garcia, F. Freire, Energy **176**, 1 (2019)
10. J. Teixidó-Figueras, J.K. Steinberger, F. Krausmann, H. Haberl, T. Kastner, Ecological Indicators **62,** 1 (2016)
11. Z. Zhang, X. Chen, P. Heck, B. Xue, Y. Liu, Resources, Conservation and Recycling **101,** 1 (2015)
12. H. Sun, M. Mohsin, M. Alharthi, Q. Abbas, Journal of Cleaner Production **25,** 1 (2020)
13. K.K. Eluwole, S.S, Akadiri, A.A., Alola, M.U, Etokakpan, Science of The Total Environment **705,** 1 (2020)
14. European Environment Agency, Greenhouse Gas Data Viewer. https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer (10 July 2022)
15. European Environmental Agency, Air Pollutant Emissions Data Viewer https://www.eea.europa.eu/data-and-maps/dashboards/air-pollutant-emissions-data-viewer-1 (10 July 2022)
16. Eurostat, National accounts and GDP https://ec.europa.eu/eurostat/ (31 July 2023)
17. Lovins, *A, Reinventing Fire: Bold Business Solutions for New Energy Era. White River Junction*, (Chelsea Green Publishing, 2011)
18. Alexander, S.A, *WP 1/14. Post Carbon Pathways Project*, (Melbourne Sustainable Society Institute, 2014)
19. G.L. Kyriakopoulos, I. Sebos, Climate **11,** 5 (2023)
20. S. Akkermans, J.L. Martín-Ortega, I. Sebos, M.J. López-Blanco, Mitig Adapt Strateg Glob Change **28**, 19 (2023)
21. A. Progiou, N. Liora, I. Sebos, C. Chatzimichail, D. Melas, Sustainability **15**, 2 (2023)
22. I. Sebos, L. Kallinikos, Atmosphere **14** 24 (2023)
23. A.G. Progiou, I. Sebos, A.M. Zarogianni, E.M. Tsilibari, A.D. Adamopoulos, P. Varelidis, Environmental Engineering and Management Journal **21** 5 (2022)