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ACTIVITY OF POLISH ORGANISATIONS PARTICIPATING IN THE EMAS SCHEME TO REDUCE THE EMISSION OF AIR CONTAMINANTS

Jadwiga NYCZ-WRÓBEL

Rzeszow University of Technology, Department of Management Systems and Logistics;
jnw@prz.edu.pl, ORCID: 0000-0002-2100-6765

Purpose: The purpose of this paper was to present the undertakings of Polish enterprises participating in the EMAS scheme, dealing with waste and sewage management, water supply and land reclamation, implemented in order to reduce air contaminants emissions.
Design/methodology/approach: The assumed research method was based on the analysis of secondary sources in form of environmental statements. The selection of sample was targeted and the research involved a complete analysis among 19 companies participating in the EMAS scheme, selected based on their business profile and dealing with waste and sewage management, water supply and land reclamation. The analysis described herein allowed to identify most common initiatives aimed at reduction of emissions and indicate specific solutions applied in that area.
Findings: Most frequent solutions include: vehicle replacement, use of renewable sources of energy, use of low-emission technologies, devices or systems, failure prevention systems, monitoring, analysis and measurement of emissions. Possibilities to apply specific solutions have been indicated considering different profiles of activity.
Research limitations/implications: The fact that data in environmental reports are not uniform, which makes them difficult to analyse, is the limitation of the described research. Exemplary solutions are not provided in all environmental reports. Further research might focus on the analysis of initiatives taken by Polish manufacturing or power engineering companies in the area of waste management.
Practical implications: The key input of the described research is the list of specific solutions that could be implemented in organisations with different profiles of activity in order to reduce emissions of air contaminants.
Social implications: Exemplary solutions beneficial in terms of air quality improvement, and also general life quality improvement, have been presented.
Originality/value: The outcome of this study may supplement previous research concerning the EMAS scheme, providing specific examples of solutions that could be implemented in organisations to reduce emissions of air contaminants.
Keywords: EMAS scheme, environmental policy, greenhouse gas, reduced emissions.
Category of the paper: Research paper.

1. Introduction

One of the major challenges within the European Union is tackling climate changes. Its importance has been highlighted, among others, in the European Green Deal, a new growth strategy which sets the goal to reach net zero emission of greenhouse gases in the European Union until 2050 (COM (2019) 640 final). The proposed climate neutrality measures include greater reduction of emissions, reaching at least 55% as compared with the values set in 1990 (Regulation (EU) 2021/1119, 2021). Seeking effective solutions to reduce emission of air contaminants is a long lasting process that requires involvement, not only at the EU level, but also in individual member states. Additionally, this initiative should have the form of a top-down framework and directions of activities set at the international or national level, and voluntary resolutions adopted by different organisations. One of the instruments that can be used in order to reduce emission of air contaminants is the eco-management and audit scheme (EMAS) introduced by the European Union. Currently, it is considered the most credible and clear environmental management system, with the primary aim of supporting different organisations in continuous improvement of environmental performance (which includes the area of emissions).

This paper is an attempt to extend the knowledge concerning particular activities undertaken by Polish organisations participating in the EMAS scheme to reduce the negative impact or increase the positive impact on environment. Filling this gap is particularly important considering the fulfilment of the EU climatic goals, taking initiatives to ensure the "healthy planet for all" (COM(2021) 400 final) and presenting out of the box solutions adopted in the analysed organisations to reduce emissions of greenhouse gases, that could inspire or be readily implemented by other organisations. Presenting exemplary activities might supplement the measures planned and implemented in individual countries to improve air quality, which is also a key element of life quality improvement.

2. Importance of EMAS scheme for climate neutrality

As it has already been mentioned, the EU has set an ambitious goal to reach climate neutrality until 2050. Its fulfilment strongly depends on multilevel cooperation (international, European, national, regional, local) between organisations in different sectors. The schedule and types of major initiatives leading to the reduction of air, water and soil contamination have been formulated in the zero waste hierarchy. According to this hierarchy, the basis for the EU policy should be preventive activities related to all stages of contaminants emissions, from the extraction of natural resources, through production, services and supply,

to consumption. In this context, this policy particularly encourages implementing zero-emission production processes, design of safe and sustainable products or services, using innovative tools and technologies, and changing consumption habits. When it is impossible to eliminate the source of contamination, further activities, according to the zero-emission hierarchy, should focus on reduction. Modern and smart solutions within production processes, using safe and sustainable products, services and business models, as well as digital solutions for tracking and reducing contamination should be particularly promoted in this area. Another type of activities, mentioned as the last resort in the zero-emission hierarchy, is repair and compensation for damage caused as a result of the release of contaminants (COM(2021) 400 final).

Fulfilment of the EU climatic goals will also depend on setting top-bottom framework of action and taking voluntary initiatives by organisations and bodies whose activity is more or less related to producing air contaminants. The EMAS scheme is one of the tools that could be used in different economic sectors. Its basic goal is to support organisations in continuous improvement of their environmental performance, which somehow forces them to seek new (innovative) or better solutions. As regards the hierarchy of contamination management activities, the EMAS scheme can support businesses in the fulfilment of two prioritized types of activities, related to preventing or reducing emissions. Organisations participating in the EMAS scheme are additionally obliged to present regular reports on their improvement in six environmental areas: energy efficiency, efficient usage of materials, water, waste, biodiversity and emissions. As regards the last of the listed areas, the evaluation encompasses total yearly emission of greenhouse gas (at least emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6), in tonnes of carbon dioxide equivalent, and total yearly emissions to air (at least SO_2, NO_X and PM), in kilograms or tonnes (Regulation (EC) No. 1221/2009, 2009). The organisations participating the EMAS scheme present their performance as part of a public environmental report which must be delivered and updated as the requirement of the participation. When it comes to preventing or reducing emission of air contaminants, it should be mentioned that organisations participating in the EMAS scheme are obliged to maintain conformity with relevant laws. Enterprises participating in the EMAS scheme must monitor any changes in these laws and adjust their activity accordingly. Considering the principles of climate policy, it means conformity with the following acts: The Act on the System to Manage the Emissions of Greenhouse Gases and Other Substances; Law on ozone-depleting substances and certain fluorinated greenhouse gases; Regulation of the Minister of Environment concerning the types of installation which may cause substantial pollution to particular natural elements or to the environment as a whole; Regulation of the Minister of Environment on types of installations requiring notification; Regulation of the Minister of Environment establishing cases when emission of gases or dust into the air does not require notification (Dz.U. 2009, nr 130, poz. 1070; Dz.U. 2015, poz. 881; Dz.U. 2014, poz. 1169; Dz.U. 2019, poz. 1510; Dz.U. 2010, nr 130, poz. 881).

The significance of the EMAS scheme can also be perceived with respect to the last method of contamination management listed in the hierarchy mentioned above. This is because the primary goal of the EMAS scheme is supporting organisation in continuous improvement of environmental performance. Consequently, preventive actions and reducing emission of contaminants are prioritized, which can help companies avoid exceeding acceptable level of contamination.

3. Review of previous research concerning the EMAS scheme

The previous research concerning the EMAS scheme focused mainly on explaining the reasons, barriers and benefits related to the implementation of the system. As regards the outcomes, the analysed organisations were asked about the general benefits (if any) resulting from the implementation of the EMAS scheme. Available sources indicate that environmental benefits were most common. These were mainly related to systematisation and optimising previous environmental activities (Freimann, Schwaderlapp, 1996; Hillary, 1998; Bohne, 2000; Steger, 2000; Umweltbundesamt, 2000; Kossler et al., 2002; Morrow, Rondinelli, 2002; Hyršlova, Hajek, 2005, 2006; Abeliotis, 2006; Ministerio De Medio Ambiente, 2006; Nycz-Wróbel, 2016a); limiting the negative environmental effect, mainly through the reduction of produced waste and consumption of resources and energy (Bültmann, Wätzold, 2000; Schucht, 2000; Umweltbundesamt, 2000; Braun, Grotz, 2002; Wenk, 2004; Hyršlova, Hajek, 2006; Vernon et al., 2009; Nycz-Wróbel, 2016a) and also improvement of environmental performance (Hillary, 1998; Morrow, Rondinelli, 2002; Hillary, 2004; Daddi et al., 2011; Merli et al., 2014; Nycz-Wróbel, 2016a). However, in certain studies organisations reported particular improvement in emission of air contaminants. It concerned French (Schucht, 2000) and German (Bültmann, Wätzold, 2000) companies, but in both cases, the reported level of improvement was medium. In another study conducted among German enterprises, savings were indicated as the result of the improvement in environmental performance, however, the largest savings were connected with the improvement in areas of energy and emissions (Steyrer, Simon, 2013). The positive effects of the EMAS scheme implementation also include lower percentage of failures and environmental incidents, which can be particularly important for companies whose emissions increase as a result of a failure (e.g. ignition of waste at the landfill of a waste disposal company). Benefits in this area have been reported by companies from the EU countries (Vernon et al., 2009); Czechia (Hyršlová, Hájek, 2006); Austria (Kossler et al., 2002) and Germany (Umweltbundesamt, 2000). In this case, improvement shall be the effect of conformity with the EMAS requirement for drafting special emergency readiness and responding procedures, which ensures that organisations are better prepared for hazards. Consequently, this can contribute to a reduction in frequency of incidents.

Only a few studies included questions regarding specific solutions adopted to achieve environmental performance. The study among Polish power engineering enterprises listed specific undertakings leading to reduce emissions of air contaminants. These included: using modern low-emission technologies (with renewable sources of energy), upgrade of technologies, installations and facilities, use of flue gas purification systems, measurement of emissions and process sealing (Nycz-Wróbel, 2021a). In Polish manufacturing enterprises, emissions were mainly reduced through the implementation of new technologies or upgrading already used technologies (with the use of renewable energy sources), monitoring and measurement of emissions and also modification of transport operations (Nycz-Wróbel, 2021). The research among French and German organisations only presented activities leading to the improvement of environmental performance (without indication of specific areas where improvement should be achieved). These included: optimising or introduction of new processes, technical improvement of existing facilities or installations, optimising transport operations, improvement of environmental impact of products or replacement of problematic materials (Bültmann, Wätzold 2000; Schucht, 2000). As presented in certain studies, solutions adopted in organisations can be perceived as technology (Braun, Grotz, 2002; Rennings et al., 2006; Nycz-Wróbel, 2016) or product environmental innovations (Hoffmann et al., 2003; Salomone, 2008; Nycz-Wróbel, 2016).

The studies described above enabled to identify certain environmental benefits achieved as a result of participation in the EMAS scheme. Only a few studies listed specific activities conducted to improve environmental performance in different areas related to environment. This study is an attempt to fill this gap. Presenting the results of these studies can be particularly important for managers of organisations seeking specific solutions that could be implemented in order to achieve improvement of environmental performance, including the area of emission of air contaminants.

4. Aim and method

The purpose of the paper was to present the undertakings of Polish enterprises participating in the EMAS scheme, dealing with waste and sewage management, water supply and land reclamation, implemented in order to reduce air contaminants emissions.

The theoretical part presents the assumptions of the EU hierarchy of air, water and soil contaminants management, and describes the relevant EMAS scheme requirements. Additionally, the results of previous desk-research from Poland and other countries, regarding the EMAS system have been presented, indicating a gap in the knowledge concerning particular solutions implemented by the analysed organisations in order to improve their environmental performance.

The empirical part contains the results of individual research conducted in Polish enterprises participating in the EMAS scheme, dealing with waste and sewage management, water supply and land reclamation.

The assumed research method was based on the analysis of secondary sources in form of environmental statements. These are reports obligatory for organisations participating in the EMAS scheme, that must be drawn up, published and updated on a regular basis. Information that can be found in environmental statements include exemplary activities planned or implemented to improve environmental performance in particular areas, among others, related to emissions. It is noteworthy that environmental statements are credible sources of data, as their content is regularly assessed in terms of correctness, reliability, credibility and conformity with the EMAS Regulation by a third party environmental verifier (Regulation (EC) No. 1221/2009, 2009). The analysis of environmental statements had been used as the grounds for the research in previous studies concerning the EMAS scheme, among others, describing the effects of EMAS implementation on the improvement of environmental performance (Daddi et al., 2011; Matuszak-Flejszman, 2019; Heras-Saizarbitoria, 2020; Nycz-Wróbel, 2020). Certain available studies emphasise the importance of environmental statements in searching information on technical innovations that organisations could apply in their facilities, previously implemented by other companies (Rennings et al., 2006).

Environmental statements were downloaded from the Polish EMAS website. The grounds for the study was the register dated 28 September 2023. The selection of sample was targeted and the research involved a complete analysis among 19 companies participating in the EMAS scheme, selected based on their business profile and dealing with waste and sewage management, water supply and land reclamation. Companies representing this particular sector have been chosen due to the fact that they constitute one of the three largest groups in the EMAS register, based on the division with reference to the structure of business activity. Additionally, this study will supplement the previous research concerning activities implemented to reduce emissions of air contaminants, conducted in the other two largest groups of Polish companies participating in the EMAS scheme (power engineering and manufacturing sector). For one of the companies listed in the EMAS register, environmental statement could not be retrieved, as a result of which, indicating any activities presented in their report was not possible.

Table 1 presents the characteristics of the analysed population, considering the type of activity and size of enterprise.

Table 1.
The characteristics of analysed enterprises considering the size and type of business activity

No.	Designation for study purposes*	Size of organizations	NACE code
1.	A	Large	36.00.Z; 37.00.Z
2.	B	Medium	35.1; 35.2; 38.1; 38.2; 39.0; 81
3.	C	Medium	37.00.Z; 35.11.Z
4.	D	Large	36; 37
5.	E	Small	38.1; 38.3; 39; 81; 71; 68
6.	F	Micro	38.32; 70
7.	G	Micro	38.32; 70
8.	H	Medium	38.1; 38.2; 38.3; 81
9.	I	Small	38.1; 38.2; 39.0
10.	J	Medium	Report could not be retrieved
11.	K	Medium	38.1; 81.2; 81.3
12.	L	Micro	38.32; 70
13.	M	Large	38.1; 38.3; 39.0
14.	N	Large	38.1; 38.3; 81.2
15.	O	Small	38.22
16.	P	Small	37; 38.2; 46.9; 47.9
17.	R	Medium	38.1; 38.3
18.	S	Small	38.1; 81
19.	T	Small	38.22.Z

* In order to present the results of the study, companies participating in the study have been coded with letters A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, T.

Source: individual research based on the analysis of environmental statements.

Considering the size of organisations, the analysed population consisted of four large, six medium, six small and three micro enterprises. The type of activity has been presented based on the NACE classification, which is the reference for the profile of activity considered by a third party environmental verifier in the assessment of the implemented EMAS system. The detailed characteristics of NACE codes, indicating the number of organisations dealing with particular activities, is presented in Table 2.

Table 2.
Detailed characteristics of activity performed by the analysed enterprises

NACE code	Characteristics	Number of enterprises
38.1	Waste collection	9
38.3	Materials recovery	5
38.2	Waste treatment and disposal	4
37/37.00.Z*	Sewerage	4
39/39.0	Remediation activities and other waste management services	4
81	Services related to buildings and landscape activities	4
38.32	Recovery of sorted materials	3
70	Activities of head offices; management consultancy activities	3
36/36.00.Z*	Water collection, treatment and supply	2
38.22/38.22.Z*	Treatment and disposal of hazardous waste	2
81.2	Cleaning activities	2
35.1	Electric power generation, transmission and distribution	1
35.11.Z*	Production of electricity	1
35.2	Manufacture of gas; distribution of gaseous fuels through mains	1
46.9	Non-specialised wholesale trade	1
47.9	Retail trade not in stores, stalls or markets	1

cont. Table 2.

68	Real estate activities	1
71	Architectural and engineering activities; technical testing and analysis	1
81.3	Landscape service activities	1

* Subclasses listed according to the Polish Classification of Activities (PKD).

Source: individual research based on the analysis of environmental statements.

Among the analysed enterprises, the largest groups deal with waste collection (9) and recovery of materials (5). Another significant groups of companies are those dealing with waste processing and neutralisation (4), sewage disposal and water treatment (4), land reclamation and other services related to waste management (4), building cleaning services, green area management and recovery of materials from sorted waste (3).

The study was conducted from 8 September 2023 until 31 October 2023. A preliminary in-depth analysis of entire environmental statements of individual companies participating in the study has been performed. Based on the conducted analysis, all types of activities aimed reducing emissions of air contaminants, implemented in Polish organisations, have been listed. Next, the identified activities were listed and grouped. The outcome has been presented in form of a chart. Table 3 presents the most frequently performed activities. Tables 4 to 8 present specific solutions applied as part of particular undertakings listed in Table 3.

5. Research outcomes

Table 3 presents the most common initiatives taken to reduce emissions of air contaminants among Polish enterprises dealing with waste and sewage management, water supply and land reclamation.

Table 3.
Most common activities performed among Polish organisations to reduce emissions

Activities	**Number of enterprises**
Upgrading vehicle fleet	9
Using renewable sources of energy	6
Using low emission equipment and installations or upgrade of systems	5
Use of technologies allowing to reduce emissions	4
Other	7

Source: individual research based on the analysis of environmental statements

The most common solutions adopted to reduce emissions of air contaminants include upgrading vehicle fleet (9), use of renewable sources of energy (6), use of low emission equipment and installation or upgrade of systems (5), and use of low emission technologies (4). A group of other activities has also been identified, including different solutions adopted in the analysed organisations to control emissions (7).

Table 4 presents specific solutions used in relation to the operated vehicle fleet.

Table 4.
Solutions applied in Polish enterprises to reduce emissions related with vehicle operation

Upgrading vehicle fleet	Enterprise	Number of enterprises
Replacement or extending vehicle fleet	D, E, H, K, M, N, R	7
Introducing additional indicator for vehicle fleet upgrade	E, M, R	3
Planned purchase of new vehicles	H, K, N	3
Use of low-emission vehicles	B, N	2
Decommissioning of vehicles	K	1
Optimum management of vehicles and fuel-consuming machines	O	1

Source: individual research based on the analysis of environmental statements.

The research indicates that the most commonly adopted solution in vehicle fleet modernisation was replacement of old vehicles. Seven companies decided to do that (D, E, H, K, M, N, R). When replacing vehicles, choosing those conforming to higher emission standards (e.g. Euro 6), or using a different drive (electric, CNG or diesel), was a priority. Two of the analysed companies (B, N) reported in their environmental statements that they had already used low-emission vehicles, while three enterprises (H, K and N, already using low-emission vehicles in their fleet) intended to buy new vehicles. When planning a purchase, as in the case of vehicle replacement, choosing zero or low-emission cars, conforming to higher emission standards (Euro 6), or using a different drive (CNG), was a priority. Three enterprises participating in the study used an additional indicator for fleet modernisation, to assess their performance in that area (E, M, R). Other activities consisted in decommissioning outdated vehicles (Euro 2 standard) and optimum vehicle fleet management. These solutions were adopted in individual enterprises.

Table 5 presents specific solutions adopted to switch to renewable energy sources.

Table 5.
Usage of renewable energy sources in Polish enterprises

Use of renewable sources of energy	Enterprise	Number of enterprises
Producing electric energy and heat using renewable energy sources	B, C, D, I	4
Photovoltaic installations or microinstallations	A, B, D, P	4
Modernisation of energy management facilities at a sewage treatment plant to use biogas for electric energy and heat production	D	1
Construction of a biogas plant	P	1

Source: individual research based on the analysis of environmental statements.

In most cases, the usage of renewable energy sources involved production of electric energy and heat, and also using photovoltaic installations or microinstallations. Each of these solutions was adopted in four enterprises. Two companies (B, D) produced electric energy and heat for own purposes and for clients, company I recovered landfill gas, and company C used biogas in that process. Beside that, other undertakings involving the use of biogas can be identified among these companies. One of them consisted in plant modernisation to allow the use of biogas in the production of electric energy and heat (D), while the other was construction of a biogas plant (P).

Polish enterprises also used low-emission equipment or installations (Table 6).

Table 6.
Equipment and installations used by Polish enterprises

Usage/modernisation of equipment or installations	Enterprise	Number of enterprises
Use of air conditioning devices containing less than 3 kg of coolant and releasing less than 5 tonnes of CO_2 equivalent F-gases	H, K, N	3
Use of air conditioning devices containing less than 3 kg of R410A or R404A and R410A or R32 coolant		
Modernising local boiler plants used for heating of company buildings (replacement of coal fired boilers with oil or gas fired boilers). Yearly technical inspection of air conditioning units. Refilling coolant in air conditioning units	D	1
Upgrade of existing emissions capture and reduction systems. Purchase and installation of new equipment	O	1

Source: individual research based on the analysis of environmental statements.

Most of activities reported by the analysed organisations concerned air conditioning systems. Keeping a proper level of cooling medium (e.g. by refilling) and CO_2 equivalent of fluorinated greenhouse gases was very important.

Another group of solutions included low-emission technologies (Table 7).

Table 7.
Low-emission technologies used in Polish enterprises

Use of technologies allowing to reduce emissions	Enterprise	Number of enterprises
Trenchless repair of sewage systems	A	1
Using a new insert at a sulphur-recovery plant	C	1
Use of modern solutions to reduce emissions from mechanical and biological treatment of municipal waste	E	1
Considering current weather conditions and weather forecasts when conducting significant processing activities in open space	H	1
Proper processing, recovery, recycling and neutralisation of waste (according to BAT). Performing all waste processing operations indoors. Organised release of exhaust air from the production hall using fan discharge units	O	1

Source: individual research based on the analysis of environmental statements.

Five organisations provided specific examples of technologies in their environmental statements. These included rather expensive solutions, e.g. trenchless repair of sewage system to avoid closing roads and redirecting traffic, which allows to reduce emissions from fuel combustion (A). Another significant solution was replacing bog iron ore with a new insert in a sulphur-recovery installation at a sewage treatment plant, to remove hydrogen sulphide from biogas (C). Desulphurisation is a result of chemical reactions in which bonds between hydrogen sulphide and trivalent iron are formed. If the concentration of hydrogen sulphide in biogas rises during the desulphurisation process, insert must be replaced. This solution allowed complete desulphurisation of fuel (biogas) and reaching zero emission of SO_2. Other solutions reported by the waste management company consisted in planning processes to be performed in open

spaces based on current weather conditions (H). Consequently, pile forming and displacement, sieving and grinding operations were restricted in unfavourable weather conditions, and piles were formed so that the smallest area of compost was exposed to wind. Another waste management company (O) reported proper performance of all waste treatment operations, considering the possibilities to reduce emissions in each particular process.

The analysis of environmental statements also allowed to identify other activities performed in Polish enterprises to reduce emission of air contaminants (Table 8).

Table 8.
Other activities implemented in Polish organisations to reduce emissions

Other activities	**Enterprise**	**Number of enterprises**
Purchase of cameras to ensure CCTV system coverage of the entire waste processing site	H, P, T	3
Construction of a fire-fighting water tank with the minimum capacity of 432 m^3		
Training for employees in OHS rules and safety procedures. Constant supervision of conformity with relevant procedures. Regular inspection of equipment and buildings. Maintenance of fire-fighting installations and equipment. Specifying requirements for transport of waste (vehicle class, ADR certificate of the carrier) and procedures defining the scope and methods of verification		
In-depth analysis of sources and scale of emissions related to processing operations. Outsourcing and conducting measurements of dust emissions in individual processing operations and consulting results with the integrated environmental permit. Hiring a third party specialist in industrial dedusting systems to perform analysis and propose technical solutions for further reduction of dust emissions	A, H, O	3
Monitoring and monthly measurement of landfill gas emissions (methane, carbon dioxide and oxygen) at each landfill gas extraction well		
Documenting all data related to environmental performance to control levels of emissions		
Social campaigns	A	1
Implementing a project aimed at effective reduction of emissions from a sewage treatment plant	C	1
Notification on the use of a system not requiring permission to release gases and dust into the air	E	1
Drafting an investment and organisational framework based on the measurement of total emissions. Maintaining proper efficiency of machines and equipment	O	1
Training employees in reducing low emissions of air contaminants. Encouraging employees to use low-emission transport. Introducing a programme to reduce commuter emissions. Promotion of cycling within the organisation. Introducing an indicator to monitor the number of employees using low-emission transport	P	1
Planting trees at the area of 450 m^2. Closure and reclamation of landfill. Appointment of environmental protection teams	H	1

Source: individual research based on the analysis of environmental statements.

The group of other activities mostly involved monitoring, analysis or measurement of emissions (A, H, O) and preventing environmental incidents (H, P, T). The latter type of activities was reported by enterprises dealing with waste management, because ignition of

waste is particularly dangerous, considering emission of air contaminants. The analysed enterprises performed activities aimed at preventing incidents within their own plants, and also beyond their premises (specifying waste handling requirements). The research participants were also involved in raising awareness among their employees through training, special actions (e.g. commuter's emission reduction programme promoting low-emission transport and annual cycling events) and appointment of workgroups (to raise awareness and promote environmental activity among employees, suppliers and subcontractors, and introduce environmental initiatives). Worth mentioning in this group is a special social campaign held by a water supply and sewage company titled "Drink tap water" (A). Its goal was to promote drinking tap water instead of buying bottled water, drawing attention to the benefits of reducing the carbon footprint (which is much lower when water is supplied through the network rather than delivered in bottles).

6. Discussion

The described research allowed to identify activities most commonly adopted in Polish enterprises dealing with waste and sewage management, water supply and land reclamation to reduce their emissions. These included: replacement of vehicle fleet, use of renewable sources of energy, considering emissions when applying new technologies, devices and installations, adopting appropriate solutions to prevent environmental incidents and also monitoring, analysis and measurement of emissions. Comparing these outcomes with the previous research, we can conclude that the types of activities performed to improve organisations' environmental performance are not much different. Most of them concern the use of technology, devices and installations, irrespective of the environmental area in which improvement is expected. As far as reduction of air contaminants is concerned, we can also notice that the type of undertakings is quite similar, regardless of the profile of activity. Comparing the results obtained among the Polish enterprises dealing with waste and sewage management, water supply and land reclamation, and Polish power engineering and manufacturing companies participating in the previous research, we can identify most common solutions aimed at reducing emissions in each individual group. These included use of low-emission technologies, equipment or installations, use of renewable sources of energy and also emission monitoring and measurement systems. Considering the profile of activity, we can also indicate process sealing solutions (adopted in companies from the power engineering and waste management sectors), and also fleet upgrade with vehicles conforming to higher emission standards or using a different type of drive (manufacturing and waste handling companies).

Considering the presented hierarchy of contaminants management, the importance of the EMAS scheme should be emphasised for two recommended types of activities, namely preventing and reducing contamination. As the described research shows, most initiatives taken among the analysed enterprises consisted in preventing or reducing emissions (this study was focused on emissions of air contaminants, but EMAS scheme can be equally important for the two other types of contaminants mentioned in the hierarchy). The EMAS scheme, with its restrictive requirements (e.g. continuous improvement of environmental performance, maintaining legal conformity and preventing environmental incidents), helps organisations avoid excessive environmental impact (e.g. increased emission). That is why its significance must be considered with reference to the last type of activities mentioned in the hierarchy, that should be used only as a last resort, namely the repair and compensation of damage occurring as a result of contamination.

Based on the described research, we can formulate recommendations for managers of organisations who seek inspirations or out of the box solutions that could be adopted in their companies to prevent or reduce emissions of air contaminants:

- The first area where improvement possibilities should be sought is the technology, equipment or installations – as the study suggests, in these particular areas most of the analysed companies took action to improve their environmental performance, irrespective of the profile of their activity. Despite the fact that these solutions are related with the highest cost, and in many cases return on investment can be a long perspective, we could identify one less expensive activity, namely considering weather conditions when performing operations in which higher dust emissions occur.
- Companies whose major sources of emissions include transport and handling operations, should consider purchase of vehicles conforming to higher emission standards or using a more environmentally friendly drive (e.g. CNG or electric).
- In organisations where increased emission can occur as a result of a failure, taking preventive actions is very important. And again, the study shows that less expensive solutions can also be adopted in this area (e.g. introducing and controlling conformity with safety procedures for internal and external operations). These solutions could be adopted in different organisations relying on relatively limited resources.
- Another undertaking that can, depending on the adopted solutions, entail more or less significant cost, is the emissions monitoring, analysis and measurement system. It can be applied in any organisations, regardless of their profile. Here, they can seek assistance of third party experts (e.g. laboratories certified by the Polish Centre for Accreditation) or conduct monitoring and measurements on their own (e.g. using indicators specified in the EMAS Regulations or developed individually).
- In organisations whose operations cause increased emission of dust, tightening of industrial processes is recommended.

- Using renewable sources of energy is also worth considering, which can not only reduce CO_2 emission but can also help improve environmental performance of an organisation.
- Organisations with smaller financial potential or conducting activity not related with high emission of air contaminants, intending to improve their environmental performance in this and other fields, could introduce training and awareness-raising courses for employees or other stakeholders cooperating with the organisation, appoint environmental teams whose duties could be adjusted to individual needs, conduct interesting environmental campaigns for employees or external stakeholders, and develop an own set of indicators to assess improvement in a selected environmental area.
- The hierarchy of contamination management activities, recommended by the EU, should be also considered, with the emphasis on preventing and reducing emissions.

As it has already been mentioned, the outcomes of this study can supplement previous research concerning the EMAS scheme, providing specific examples of solutions that could be adopted in organisations to improve their environmental performance. The fact that data in environmental reports are not uniform, which makes them difficult to analyse, is the limitation of the described research. Some organisations did not present examples of specific activities in their environmental statements. However, the analysis indicated activities that could inspire or be readily implemented to reduce emissions of air contaminants in different organisations.

7. Conclusions

The purpose of the paper was to present the undertakings of Polish enterprises participating in the EMAS scheme, dealing with waste and sewage management, water supply and land reclamation, implemented in order to reduce air contaminants emissions. The research allowed to identify examples of specific solutions commonly adopted in this area. These included: vehicle replacement, use of renewable sources of energy, use of low-emission technologies, devices or systems, failure prevention systems, monitoring, analysis and measurement of emissions. The key input of the described research are examples of specific activities that could inspire or be readily implemented in different organisations. It is particularly important considering the principles of the EU climate policy, but also the quality of life of the society. This paper supplements the previous research concerning the EMAS scheme.

The described research does not provide sufficient information to fill the gap in the knowledge concerning the activities performed by organisations participating in the EMAS scheme to improve their environmental performance. Therefore, areas of further study in this field should be indicated, e.g. undertakings of Polish manufacturing or power engineering enterprises related to waste management.

References

1. Abeliotis, K. (2006). A review of EMAS in Greece: is it effective? *Journal of Cleaner Production, 14*(18), 1644–1647.
2. Annex to the Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions The European Green Deal. COM (2019) 640 final.
3. Bohne, E. (2000). Voluntary Environmental Management Systems and Regulatory Relief. In: C.F. Bonser (Eds.), *Security, Trade, and Environmental Policy* (pp. 207-217). Boston, MA: Springer.
4. Braun, B., Grotz, R. (2002). Environmental Management in Manufacturing Industry: A Comparison Between British and German Firms. In: L. Schätzl, J.R. Diez (Eds.), *Technological Change and Regional Development in Europe* (pp. 273-292). Heidelberg: Physica.
5. Bültmann, A., Wätzold, F. (2000). *The Implementation of the European EMAS Regulation in Germany.* Leipzig/Halle: UFZ. Retrieved from: https://www.researchgate.net/publication/265196953_The_Implementation_of_the_European_EMAS_Regulation_in_Germany, 1.09.2021.
6. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' COM(2021) 400 final.
7. Daddi, T., Magistrelli, M., Frey, M., Iraldo, F. (2011). Do environmental management systems improve environmental performance? Empirical evidence from Italian companies. *Environment Development and Sustainability, 13*(5), 845-862.
8. Freimann, J., Schwaderlapp, R. (1996). Implementation of the EU's EMAS Regulation in German companies. *Corporate Social Responsibility and Environmental Management, 3*(3), 109-112.
9. Heras-Saizarbitoria, I., Boiral, O., García, M., Allur, E. (2020). Environmental best practice and performance benchmarks among EMAS- certified organizations: An empirical study. *Environmental Impact Assessment Review, 80.*
10. Hillary, R. (1998). *An Assessment of the Implementation Status of Council Regulation (No. 1836/93) Eco-management and Audit Scheme in the Member States (AIMS-EMAS), Final Report*. Retrieved from: http://aei.pitt.edu/38669/1/A3501.pdf, 1.09.2021.
11. Hillary, R. (2004). Environmental management systems and the smaller enterprise. *Journal of Cleaner Production, 12*(6), 561-569.
12. Hoffmann, E., Ankele, K., Nill, J., Rennings, K. (2003). Product innovation impacts of EMAS: Results of case studies and a survey of German firms validated according to the

EU environmental management and auditing scheme. *The Journal of Sustainable Product Design, 3*(3), 93-100.

13. https://www.gov.pl/web/gdos/emas, 28.09.2023.
14. Hyrslová, J., Hájek, M. (2005). Environmental Management Accounting in the Framework of EMAS II in the Czech Republic. In: P.M. Rikhardsson, M. Bennett, J.J. Bouma, S. Schaltegger (Eds.), *Implementing Environmental Management Accounting: Status and Challenges. Eco-Efficiency in Industry and Science, 18*. Dordrecht: Springer.
15. Hyršlová, J., Hájek, M. (2006). Environmental Management Accounting in Czech Companies that have Implemented Environmental Management Systems. In: S. Schaltegger, M. Bennett, R. Burritt (Eds.), *Sustainability Accounting and Reporting*. Dordrecht: Springer.
16. Kössler, W., Promberger, K., Stichauner, B., Waidhofer, S. (2002). *Evaliuierung der Umsetzung der EMAS I–VO in österreichischen Unternehmen*. Universität Innsbruck. Retrieved from: https://www.verwaltungsmanagement.at/602/uploads/10650109920.pdf, 1.09.2021.
17. Matuszak-Flejszman, A., Szyszka, B., Jóhannsdóttir, L. (2019). Effectiveness of EMAS: A case study of Polish organisations registered under EMAS. *Environmental Impact Assessment Review, 74*, 86-94.
18. Merli, R., Preziosi, M., Massa, I. (2014). EMAS Regulation in Italian Clusters: Investigating the Involvement of Local Stakeholders. *Sustainability, 6*(7), 4537-4557.
19. Ministerio De Medio Ambiente (2006). *Opinion study on the revision of regulation (EC) # 761/2001 (EMAS).*
20. Morrow, D., Rondinelli, D. (2002). Adopting Corporate Environmental Management Systems: Motivations and Results of ISO 14001 and EMAS Certification. *European Management Journal, 20*(2), 159-171.
21. Nycz-Wróbel, J. (2016). Znaczenie implementacji Systemu Ekozarządzania i Audytu (EMAS) w kontekście kształtowania innowacyjności przedsiębiorstw. *Marketing i Rynek, 7/2016*, 618-630.
22. Nycz-Wróbel, J. (2016a). Znaczenie implementacji systemu Ekozarządzania i Audytu (EMAS) w kontekście wzmacniania konkurencyjności przedsiębiorstw. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Zarządzanie strategiczne w teorii i praktyce nr 444*, 381-390.
23. Nycz-Wróbel, J. (2020). Realizacja założeń polityki energetycznej w polskich przedsiębiorstwach zarejestrowanych w systemie EMAS. *Studia i Materiały, 1*, 47-58.
24. Nycz-Wróbel, J. (2021). Activities undertaken by Polish manufacturing companies to reduce air emissions. *Problems and Perspectives in Management, 19*(3), 309-320.
25. Nycz-Wróbel, J. (2021a). Solutions Used by Polish Power Engineering Companies Registered in EMAS In Order to Reduce Emission of Air Contaminants. In: K.S. Soliman

(Eds.), *Innovation Management and Sustainable Economic Development in the Era of Global Pandemic.* IBIMA.

26. Obwieszczenie Ministra Środowiska z dnia 22 lipca 2019 r. w sprawie ogłoszenia jednolitego tekstu rozporządzenia Ministra Środowiska w sprawie rodzajów instalacji, których eksploatacja wymaga zgłoszenia Dz.U. 2019, poz. 1510 (2019).
27. Regulation (EC) no 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), repealing Regulation (EC) No 761/2001 and Commission Decisions 2001/681/EC and 2006/193/EC.
28. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').
29. Rennings, K., Ziegler, A., Ankele, K., Hoffmann, E. (2006). The influence of different characteristics of the EU environmental management and auditing scheme on technical environmental innovations and economic performance. *Ecological Economics, 57*(1), 45-59.
30. Rozporządzenie Ministra Środowiska z dnia 2 lipca 2010 r. w sprawie przypadków, w których wprowadzanie gazów lub pyłów do powietrza z instalacji nie wymaga pozwolenia Dz.U. 2010, nr 130, poz. 881 (2010).
31. Rozporządzenie Ministra Środowiska z dnia 27 sierpnia 2014 r. w sprawie rodzajów instalacji mogących powodować znaczne zanieczyszczenie poszczególnych elementów przyrodniczych albo środowiska jako całości Dz.U. 2014, poz. 1169 (2014).
32. Salomone, R. (2008), Integrated management systems: experiences in Italian organizations. *Journal of Cleaner Production, 16*(16), 1786-1806.
33. Schucht, S. (2000). *The Implementation of the Environmental Management and Eco-Audit Scheme (EMAS) Regulation in France, Research Paper 2000-B-2*. CERNA.
34. Steger, U. (2000). Environmental management systems: empirical evidence and further perspectives. *European Management Journal, 18*(1), 23-37.
35. Steyrer, T., Simon, A. (2013). *EMAS in Germany Evaluation 2012*. BMU/UBA. Retrieved from: https://www.umweltbundesamt.de/publikationen/emas-in-germany-evaluation-2012, 14.09.2021.
36. Umweltbundesamt (Hrsg.) (2000). *EMAS in Germany, Report on Experience 1995 to 1998*. Umweltbundesamt Germany. Retrieved from: https://www.umweltbundesamt.de/en/publikationen/emas-in-germany-report-on-experience-1995-to-1998, 1.09.2021.
37. Ustawa z dnia 15 maja 2015 r. o substancjach zubożających warstwę ozonową oraz o niektórych fluorowanych gazach cieplarnianych, Dz.U. 2015, poz. 881 (2015).
38. Ustawa z dnia 17 lipca 2009 r. o systemie zarządzania emisjami gazów cieplarnianych i innych substancji, Dz.U. 2009, nr 130, poz. 1070 (2009).

39. Vernon, J., Peacoc, M., Belin, A., Ganzleben, C., Candell, M. (2009). *Study on the Costs and Benefits of EMAS to Registered Organisations*. Milieu Ltd., Risk and Policy Analysis Ltd. Retrieved from: https://ec.europa.eu/environment/emas/pdf/other/costs_and_benefits_of_emas.pdf, 1.09.2021.
40. Wenk, M.S. (2004). EU's Eco-Management and Audit Scheme. *Environmental Quality Management, 14*(1), 59-70.