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### AIR POLLUTION, PREVENTION AND CONTROL METHODS - THE NEED FOR CHANGE SEEN BY YOUNG PEOPLE

*Air pollution is a major problem nowadays, due to its importance as a source of other environmental problems, such as global warming and climate change, as well as their impact on worldwide health. Different studies support that this situation can be turned around, by applying diverse actions at different scales; individual, industrial and governmental.*

*The exemplary programmes presented in this paper can be easily adapted by the interested and with their help education for sustainable development (including activities for clean air), can be implemented, similarly to the Faculty of Biology and Agriculture at the University of Rzeszów.*

**Key words:** air pollution, sustainable development, prevention, control, educational programmes

#### I. INTRODUCTION

Achieving sustainable development through a harmonious combination of economic growth with the requirements of environmental protection and participation in building a civil society is a serious challenge for all citizens of the world. In the last 200 years, humankind have devastated a huge part of the natural environment [Riahi et al. 2017, Nicolescu 2018], which should force us to change our behaviour dramatically. It is worth replacing the vicious anthropocentric vision of man's place on Earth with an ecocentric perspective in which man occupies an important but undefined position among other elements of nature [Kostecka 2013]. Among the major megatrends (demographic, globalization, scientific progress, the new industrial and technical revolution, the disappearance of nation states), the megatrend of ecological threats is also shown. It concerns both the natural world and the social world, creating a mutually related systemic unity [Gawor 2017].

Air pollution is becoming a matter of concern currently as it has been underestimated in front of another environmental problems, such as global warming or climate change, but air pollution is one of the main sources of these other problems, and solutions are required. In addition, air pollution is a major health problem worldwide; it is estimated by the World

Health Organisation (WHO) that 2.4 million people die because of the effects of air pollution on health [Sierra-Vargas and Teran 2012].

There are different components on air pollution in which scope must be set and specific measures must be taken. Among them, on the one hand is particulate matter (PM), which can be defined as a complex mixture of solid and liquid particles present in air when different fossils fuels; coal, gasoline and diesel, or wood are burned [Sierra-Vargas and Teran 2012, Gharibvand et al. 2017].

PM can also be generated by concrete chemical reactions in nature, such as nitrogen oxides, and by livestock, such as pollen grains, dust, etc.

In case of cities the main producers of PM are traffic and industry [Sierra-Vargas and Teran 2012, Hoffmann 2018]. PM can also be divided into two different categories depending on the size of the particles. Following the WHO definition, it is possible to differ into PM of less than 10 microns of diameter (PM10) and PM of less than 2.5 microns of diameter (PM2.5) [Database ... 2018].

On the other hand, there are different gases that contribute to the air pollution. These vary depending on the region, legislation and type of industry, some examples are: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), nitrogen oxide (NO<sub>x</sub>), sulphur oxide (SO<sub>x</sub>), carbon monoxide (CO), non-methane volatile organic compound (NMVOC), and ammonia (NH<sub>3</sub>) [Fujii and Managi 2016]. Good air quality, next to water and food, is the basic resource that should be taken care of for the inhabitants of the entire planet.

The aim of the article is to show basic facts about air pollution, prevention and control methods, as well as to present current initiatives to mobilize participation in necessary changes in behaviour and organization of life, mainly at the level of an individual citizen, industrial and governmental scales.

## II. CURRENT SITUATION

Different organisations are fighting against this problem by setting limits and pressuring different countries, to reduce its contribution to air pollution. EU and WHO are the most important ones, despite of this, as it is observed in table 1 and figure 1, this is not working properly. A concrete and common index/limit is needed and more restrictive efforts must be done. In table 1 comparison are drawn between EU and WHO limits which shows conflicting views.

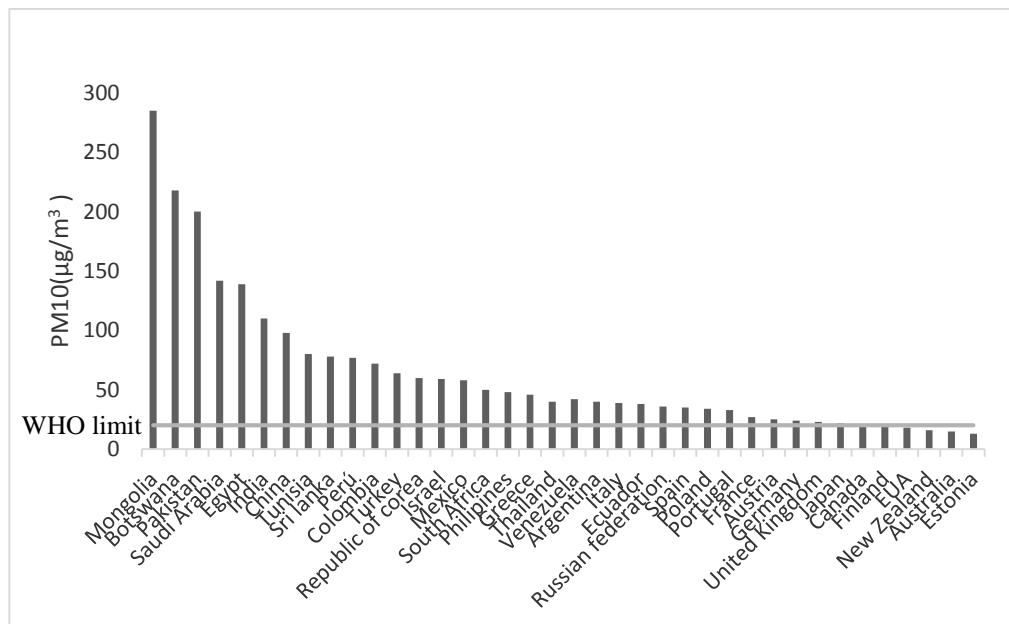
**Table 1 – Tabela 1**

Comparative air pollution limits between EU and WHO / Porównanie granic zanieczyszczeń powietrza między UE a WHO

Pollutant <i>Zanieczyszczenie</i>	EU limit <i>EU norma graniczna</i>	Urban population exceeding EU limit (%) <i>Odstetek ludności w miastach przekraczający limit UE (%)</i>	WHO limit <i>WHO norma graniczna</i>	Urban population exceeding WHO limit (%) <i>Odstetek ludności w miastach przekraczający limit WHO (%)</i>
PM10	50 µg/m <sup>3</sup> in 24h	16	20 µg/m <sup>3</sup> a year	50
PM2.5	25 µg/m <sup>3</sup> a year	8	10 µg/m <sup>3</sup> a year	85
BaP	1 µg/m <sup>3</sup> a year	20	0.12 µg/m <sup>3</sup> a year	88
NO <sub>2</sub>	40 µg/m <sup>3</sup> a year	8	40 µg/m <sup>3</sup> a year	8
SO <sub>2</sub>	125 µg/m <sup>3</sup> in 24h	<1	20 µg/m <sup>3</sup> in 24h	38
O <sub>3</sub>	120 µg/m <sup>3</sup> in 8h	8	100 µg/m <sup>3</sup> in 8h	96

BaP=benzo(a)pyrene; NO<sub>2</sub>=nitrogen dioxide; O<sub>3</sub>=ozone; PM2.5= particulate matter <2.5 µm; PM10=particulate matter <10 µm; SO<sub>2</sub>= sulphur dioxide

However, in figure 1, a critical situation is observed, when there are cities that surpass the WHO limit (which is  $20 \mu\text{g}/\text{m}^3$  a year) by 15 to 10 times, and only considering PM10 values, which can be observed in table 1 as the 3rd less affecting pollutant. Nota bene the observations present on figure 1 are for cities of a determined country, so this level of air pollution cannot be extrapolated to the whole country, although figure 1 brings to light the poor legislation and control of air pollution in these countries.



**Fig. 1.** Pollution in 38 cities selected from 91 countries, as reported by the World Health Organization (WHO). Particulate matter PM10 levels  $>20 \text{ mg}/\text{m}^3$  may pose health risks

*Ryc. 1. Zanieczyszczenie w 38 miastach wybranych z 91 krajów, jak podala Światowa Organizacja Zdrowia (WHO). Zanieczyszczenie cząstkami PM10  $> 20 \text{ mg} / \text{m}^3$  może być zagrożeniem dla zdrowia*

### III. SUPPORT STUDIES

As shown, reductions in air pollution levels are required. These reductions can be achieved in many ways, and governments can play a key role. A good example is the Chinese government, which was able to reduce its air pollution highly in Beijing during the 2008 Olympic Games, according to different studies. This resulted in a 41.6% decrease in the average number of outpatient visits for asthma during the Olympics, as compared with before the games started [Li et al. 2010].

A separate study of 36 fourth-grade Beijing children, before, during and after the Beijing Olympics, showed that fractional exhaled nitric oxide (FeNO) levels were significantly lower during the period of the Olympics and increased by 16.6% in the first hours after exposure, suggesting that rapid inflammatory changes took place [Kipen et al. 2010].

Thanks to diverse studies it is also possible to establish an important premise, the less air pollution, the higher life expectancy. Studies coming from China already, put on weight this from an indirect point of view, however following studies completely support this statement. The first one is a population based study that showed significant improvements

in life expectancy in relation to reductions in PM2.5 concentrations was conducted in the United States and showed a clear relationship between reduction in fine-particle concentrations and life expectancy [Pope et al. 2009]. This observation was also confirmed in a cohort study of Swiss adults, which demonstrated that decreases in ambient PM10 levels were associated with reductions in respiratory symptoms [Schindler et al. 2009].

#### IV. SOURCES OF AIR POLLUTION

It is important to know where air pollution comes from, so as to act against it. As can be seen, anthropopressure can be controlled at different scales which will be reviewed next (table 2).

**Table 2 – Tabela 2**

Examples of environmental burdens from natural sources and humankind sources / *Przykłady obciążenia środowiskowego ze źródeł naturalnych i pod wpływem człowieka*

Examples / <i>Przykłady</i>		Proportion of environmental effects <i>Proporcja efektów środowiskowych</i>	Control <i>Kontrola</i>
Natural <i>Naturalne</i>	Dust storms, forest fires, ash from volcanoes, decay of organic matter, pollen <i>Burze piaskowe, pożary lasów, popioły z wulkanów, rozkład materii organicznej, pyłki</i>	Reduced, also in the cases the incidence could be high (a volcano producing lots of ashes), they are eventual, so they have to be analyzed in a global way / <i>Zmniejszone, także w przypadkach, gdy częstość występowania może być wysoka (np. wulkan produkuje dużo popiołów), są one ostateczne, więc muszą być analizowane w sposób globalny</i>	Not possible <i>Nie możliwe</i>
Atropo- Pressure <i>Antro- popresja</i>	Population explosion, deforestation, urbanisation and industrialization <i>Hodowla zwierząt, gatunki ekspansywne, wylesianie, urbanizacja i industrializacja</i>	Every day, and becoming higher and higher day by day / <i>Każdego dnia, z każdym dniem coraz wyżej</i>	At an individual scale, industrial scale and at governmental scale / <i>W skali indywidualnej, przemysłowej i rządowej</i>

#### *Individual scale*

As individuals, an important task is put on our shoulders, small changes in daily life can suppose huge changes when they are done collectively. First, it is important to scope the main producers of air pollution in cities; transport.

Populations should try to reduce air pollution from their motor vehicles, and there are different ways for that -using public transport, riding a bike, going for a walk. Also, to save energy is a critical point, currently energy is produced mainly by fossil fuels, so a reduction in the energy requirement, would mean a reduction of energy production and a lower air pollution derived from that production.

Nowadays, multiple eco-friendly products are emerging and is a common duty to encourage them, a fact that can be easily done by choosing sustainable products rather than more pollutant ones -for example those with plastic envelops.

3 R law -reduce, reuse and recycle- must be constantly taken into account. People need a critical point of view, and being conscious of their needs and how to fulfill them, the question is not to 'be green' or not, the question is to be responsible and complete each one needs, in a sustainable manner. To sum up, a collective transition to a sustainable behaviour is needed.

#### *Industrial scale*

At this scale, methods are much technical, so a differentiation inside air pollution must be done. In industry it is possible to find methods of controlling gaseous pollutants, and methods for controlling particulate emissions. Firstly, *gaseous pollutants* -such hydrocarbons, sulphur dioxide, carbon monoxide, etc- can be controlled by using 3 different methods.

→ Combustion: the basis of this method is to oxidize the pollutant to a less harmful product, and this oxidation can be done by different ways. 'Flame combustion' is combustion directly applying fire; 'Catalytic combustion' applying an oxidative reaction thanks to the presence of a catalyst. Mainly used in presence of pollutant organic gases or vapours.

→ Absorption: this method is based into passing the crude pollutant gas through a scrubber in which a liquid is dispersed, this liquid has more affinity for the pollutant than the gases, so the pollutants go downside with the liquid and the clean gas goes up. It is common in these scrubbers to have at the bottom another method for pollutant control, principally catalytic oxidation.

→ Adsorption: In this method, the polluted air is passed through porous solid adsorbents kept in suitable containers. The gaseous pollutants are adsorbed at the surface of the porous solid and clean air passes through.

Secondly, methods of controlling *particulate emissions* are also important; gathering from PM10 to PM2.5, methods are common for these 2 categories however small differences will appear.

→ Mechanical devices: it is a physical method, taking profit from different forces so as to make particles to precipitate from the air. This method will be easier to apply in case of PM10 as they have a greater diameter, rather than on PM2.5. Forces used in this method go from gravity to a sudden change in direction of airflow.

→ Fabric filters: filtering is one of the most famous and applied separation method. At industrial level, different filters can be made, varying the porous size depending on the target PM -PM10 or PM2.5-. Particles will stay on the filter, while the airflow is discharging. The process of controlling air pollution by using fabric filters is called 'bag filtration'.

→ Wet scrubbers: similar procedure to absorption in gaseous pollutant, although in this case the crude gas is directly passed through liquid, so the particles will remain in the liquid and the clean gas will be able to go outside.

→ Electrostatic precipitators: more modern method, in which the crude gas is passed through a precipitator where an electric current is applied, acting firstly on the PM making them to precipitate into the electrodes, and letting free the gas.

Finally, some other methods of prevention and control air pollution, common for both types, can be applied. These go from using tall chimneys so as to prevent that air pollution affects citizens health; to the use of better design equipment and smokeless fuels.

Renewable and non-polluting sources of energy are completely necessary in the sector and their apply will mean a critical point from which depart to a more sustainable world [Varsa, 2017].

### *Governmental scale*

Promotion of renewable non-pollutant energies and depletion of fossil fuels generated energies are some of main claims that governments have to deal with. However hydroelectric businesses are a “hard nut to crack”, with a lot of contacts in governments; so an aggressive legislation could lead to a conflict of interests. It is a complex affair, with lots of economic factors involved, but a proper legislation is required, people need to get rid of politics which impede a more sustainable evolution.

As motor vehicles are major contributors to air pollution, many of the initiatives to improve air quality focus on transport. Some of these initiatives are taking weight on Europe, nevertheless commentators criticised that this will not be enough. They claim Europe has not given the proper importance to air pollution prevailing above it another environmental problems such global warming or climate change -when air pollution is one of the main sources of them both.

It should be point out that not the whole responsibility resides on EU, European car manufacturers have promoted the fuel efficiency of diesel without mentioning the amount of environmental problems it could suppose, due to the higher emissions of greenhouse gases, among others [Russell-Jones 2017].

According to the European Environment Agency, air pollution in the EU accounts for 520 000 deaths annually and costs half a trillion Euros in increased health costs [European Environment Agency... 2016]. There are plenty of different measures that governments could use in this topic, but they could be sum up into:

→ Promoting low/ultra-low emission vehicles.

→ Complicate the development and use of diesel-based vehicles.

This can already be seen nowadays. Different local governments are highly involved and using legislation to make air clean areas, which would impede diesel-based vehicles to circulate. This tendency is believed to start growing until whole cities will embrace this situation or even whole countries [BBC NEWS... 2018].

Clearly there are other problems which require measures, for example the spread of aerosol-using products or different agricultural practices that involves the use of nitrogen-based fertilizers [Russell-Jones 2017].

Currently one of the most contaminated countries involving air pollution is China, with the government in a complex position. They started legislating vigorously, however this was not enough for that complicated situation.

They noticed that apart from legislation, coordination between different governmental levels is required and there were different measures that should be taken in cooperation, this was determined in May 2010, when the State Council issued the Joint Prevention and Control of Air Pollution, aiming to establish a cooperative prevention and control system for regional air pollution, which resulted into three key regions and six city clusters.

Furthermore, another issue is winning importance, and it is the problem of secondary pollutants. So for now the traditional single-pollutant approach is far from enough in China. This means in future, China’s air pollution control strategies should move in the direction of *multiple-pollutant approach*. The term used normally in Chinese government documents is ‘Co-control’ which refers to ‘coordinated control’ [Huang et al. 2017].

It is true China put themselves in a really complicated situation, nevertheless they are starting to take serious and modern strategies to fight against this air pollution.

This is an example of what different governments worldwide could do, and act before pushing the environment into an irreparable state.

## V. EXAMPLES OF EDUCATIONAL PROGRAMMES

Students and pupils are more and more concerned about the environment. Torkar [2016] provided evidence that students' concerns for the consequences of environmental damage formed three correlated factors organized around self and family, all people and the biosphere. Since humanity is facing challenges in balancing our demands and ecological limitations, the results of his study could be beneficial for further development of environmental education.

Shaping social awareness is a complex process, which depends on the degree of social acceptance of moral ideas and norms, as well as deepening knowledge about, for example, the state of the environment or the ecological effects of various forms of management and behavior. The implementation of pro-environmental activities should take the form of broad measures, which are possible thanks to well-planned programmes. The Polish Green Certificate programme developed by Honorata Waszkiewicz from the Foundation of the Ecological Education Center in Warsaw [Waszkiewicz 2009] was an example of an excellent plan enabling gradual gaining of more and more experience in the interpretation and implementation of the concept of sustainable development. This programme for many years inspired educational institutions at various educational levels to pro-environmental, prosocial and pro-economic activities. It also included the activities of a team of experts and coherent criteria and rules for its granting to kindergartens and schools at various levels of education. Through its construction, it mobilized educational institutions to cooperate with local self-government, social organizations and enterprises. In many places it caused important changes, encouraged the youngest and adult residents and local self-governments to act. The Green Certificate programme prepared local communities for changes in their immediate environment.

International experience in building sustainable development on a European scale was presented by two long-term international educational networks: under the auspices of UNESCO and UNEP in 2004-2006 and 2007-2009 CCN - Consumer Citizenship Network led by Wiktoria Wyszynski Thoresen from Hedmark University in Norway [Thoresen 2005] and PERL1 and PERL2 - Partnership for Education and Research about Responsible Living - operating (in 2010-2011 and 2012-2015) under the same management [PERL 2 ...]. Both networks were the result of cooperation between educators and researchers from over 140 institutions (including representatives of the University of Rzeszów) and 50 countries (including Poland). Education for sustainable development at the Faculty of Biology and Agriculture of the University of Rzeszów supports the introduction of various methods of active education, involving representatives of many groups of participants in a joint search for real examples of behaviour for transforming consciousness and building a new culture of sustainable life. The basis for new ideas useful for this purpose may be studies by Rozenbajger and Kostecka [2012], Kostecka and Mazur Pączka [2015] as well as Kostecka and co-authors [2015, 2018 a,b]. In case of Spain there are different educational programmes provided by 'Ministerio para la transición ecológica' [more information can be obtained from <https://www.miteco.gob.es/es/>] which can be done from the primary school to the degree level. Also different autonomous communities can support this tendency by providing different courses by themselves, such as 'Programa de Educación Ambiental' in case of Canary islands [more information can be obtained from <http://www.gobiernodecanarias.org/educacion/web/programas-redes-educativas/programas-educativos/educa-ambiental/>].

## VI. CONCLUSIONS

The search for an effective way to a sustainable lifestyle, exchange of experience and information about achievements is possible through international cooperation. An example of this can be the Erasmus programme. The **Erasmus Programme - European Community Action Scheme for the Mobility of University Students** is a European Union (EU) student exchange programme established in 1987. Erasmus Plus, is the new programme combining all the EU's current schemes for education, training, youth and sport, which was started in January 2014.

The current work shows the state of air in the 21st century and emphasized the need for urgent education in the field of natural foundations for sustainable development, with particular emphasis on this issue. The exemplary programmes presented in this study can be easily adapted by the interested and with their help education for sustainable development can be implemented, similarly to the Faculty of Biology and Agriculture at the University of Rzeszów.

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## **ZANIECZYSZCZENIE POWIETRZA, METODY ZAPOBIEGANIA I KONTROLI - POTRZEBA ZMIANY WIDZIANA PRZEZ MŁODYCH LUDZI**

### Streszczenie

*Zanieczyszczenie powietrza jest obecnie poważnym problemem, ze względu na jego znaczenie jako źródła innych problemów środowiskowych, takich jak globalne ocieplenie i zmiany klimatu, a także ich wpływ na zdrowie na całym świecie. Badania potwierdzają, że można odwrócić tę sytuację, stosując działania w różnych skalach; indywidualnej, przemysłowej i rządowej. Przykładowe programy przedstawione w opracowaniu mogą być łatwo zaadaptowane przez zainteresowanych, a przy ich pomocy można wdrożyć edukację na rzecz zrównoważonego rozwoju (z uwzględnieniem działań na rzecz czystego powietrza), podobnie jak na Wydziale Biologiczno-Rolniczym Uniwersytetu Rzeszowskiego.*

**Słowa kluczowe:** zanieczyszczenie powietrza, zrównoważony rozwój, zapobieganie, kontrola, programy edukacyjne