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Could geothermal water and energy use improve living conditions? Environmental effects from Poland

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Abstract: The issue of air pollution, resulting to a large extent from the use of fossil fuels for energy purposes, is one of the most serious environmental threats in several Polish cities, but also outside of them. The amount of pollutants emitted into the atmosphere translates into the living conditions of the inhabitants. The utilization of geothermal energy, which is a renewable and ecological source of energy, brings noticeable improvement in the quality of atmospheric air, as evidenced by significant ecological effects achieved by working geothermal district heating plants. The paper presents results of comprehensive considerations focused on assessing the effects of utilization of geothermal water and energy in Poland. Issues related to the implementation of exploration works aimed at acquiring geothermal water resources, as well as environmental aspects of the use of geothermal waters and energy were discussed. The undertaken considerations have been directed at assessing whether the use of such a kind of renewable energy resources could have an impact on improving the living conditions of the local community.

Introduction

The utilization of geothermal energy resources, in addition to many positive economic and social aspects, brings a significant number of environmental benefits. Currently, due to the constantly increasing problem of global pollution in many regions of Poland (caused mainly by use of fossil fuels and in some cases by a transportation sector), it constitutes a particularly important issue (Kaczmarczyk 2015). Geothermal energy as the internal heat of the Earth is considered as environment-friendly. It is also a strategic and sustainable source of renewable energy, therefore it does not cause significant emissions of pollutants into the natural environment (Tomaszewska and Szczepański 2014). Furthermore, it can be effectively managed in several economic sectors – beginning from energetic applications, through industrial and agricultural, up to therapeutic and recreational. The extent up to which the utilization of geothermal energy can affect the state of the natural environment (both in positive and negative ways) is proportional to the scale of geothermal resources' usage (Dickson and Fanelli 2005). What is more, each stage of geothermal projects' development can generate different environmental effects, especially in relation to the degree of air and water pollution, noise emissions, land use or impact on esthetic values of the landscape. So far, the subject area referring to the environmental impact of geothermal energy utilization has been discussed by many Polish and foreign authors. Mostly, the positive impact on the natural environment was emphasized (de Jesus 2016, Holnicki et al. 2017, Shortall et al. 2015, Towler 2014), nonetheless, the potential perils that may occur during particular stages of geothermal development were not neglected (Allis et al. 2009, Berrizbeitia 2014, DiPippo 2016, Garrido-Schneider et al. 2016). Also, the subject of broadly understood legal frameworks determining to proceed the sustainable exploitation of geothermal energy resources and to minimize the possible negative impact on the natural environment was introduced (Arias 2016, Haehnlein et al. 2010). Taking into account all legal regulations concerning the successive stages of exploration, recognition and exploitation of geothermal energy resources, it can be noticed that care for the environment is important for each of them, and possible threats are eliminated at the beginning of investment planning (Sowiżdżał et al. 2017). The evaluation of the operating geothermal installation impact on the natural environment can be made dependable on the adopted perspective – on a global or local scale. Namely, by considering the aspect of reduction on the emission of harmful substances into the atmosphere and thus the diminution of fossil fuels utilization on a global scale, or in the context of the impact of the particular geothermal installation on the local water and land environment. Therefore, the extraction and utilization of geothermal waters and energy should be considered in many aspects, both social and environmental as well as energy. The scope of utilization of geothermal resources increasingly goes beyond the sphere of already well-known applications. As an example of new directions can be the use of geothermal fluids as raw material for obtaining drinking water (Tomaszewska et al. 2014, 2018a).

Problem of energy-derived air pollution in Polish cities

For many years, Poland has been facing a huge problem of air pollution, especially during the heating season in large cities, but also outside them (Miaśkiewicz-Pęska and Szyłak--Szydłowski 2015). The main reason for lack of significant changes in gas and dust emissions to the atmosphere is that the structure of energy consumption in Poland has not been changed significantly. In national economy the coal is still the main energy source. In 2016, its share in the structure of consumption of primary energy carriers in Poland was 39.8%. The energy consumption from hard coal and biomass in households also remains high – calculated per capita, it amounts to 46%. The constitution of pollutants' emissions into the atmosphere in Poland is a derivative of the fuel consumption structure and its quality. These factors decide about the emission volume of the vast majority of air pollutants. Therefore, the high consumption of hard coal and biomass for heating buildings results in high particulates emissions. In 2016, that source was responsible for 45% of this pollutant emission to the atmospheric air in Poland. The effect of fine dust particles (PM10) and very fine dust particles (PM2.5) on people's health depends on the size of these elements and their chemical composition. The PM2.5 dust has the ability to penetrate into the deepest parts of lungs, where it is accumulated or dissolved in biological fluids, and then along with the bloodstream, is transported to the whole body. As a result, it may cause asthma, acute respiratory reactions, lung function impairment and other diseases (Dabass et al. 2016, Pun et al. 2017). Despite the observed reduction in the emission of dust precursors (especially sulphur dioxide) and actions taken to reduce concentrations of suspended particulate matter in the air, high concentrations of particulate matter PM10 and PM2.5 (Fig. 1) remain the most important problem in the context of air quality in Poland. These overruns occur both in relation to the daily standard (PM10) particulates and annual (PM10 and PM2.5) particulates. They mainly concern the territories of cities and agglomerations and in the southern Poland many non-urban areas, too.

The exceedances of the permissible daily values of PM10 dust concentrations usually occur in the winter and are mainly related to the dust emission coming from the individual heating of households and from transport.

The high emission of polycyclic aromatic hydrocarbons (PAHs), including the emission of benzo(a)pyrene, is also a derivative of the fuel consumption structure in Poland. These compounds are mainly emitted as a result of combustion of solid fuels in households. In 2016, PAH emissions from this source amounted to almost 88% of the total PAH emissions into the atmospheric air in Poland (Wiech et al. 2018).

In order to protect the natural environment in Poland and the health of society, a number of instruments focused on the reduction of pollutants emission into the atmosphere, have been established. These efforts are aimed at achieving a good state of air quality in our country. The most important of them are permits for introducing gases and dust into the air, integrated permits, emission standards for different installations, quality standards for boilers used for heating residential houses and air protection programs in areas where air quality standards have been exceeded, as well as the national air protection program.

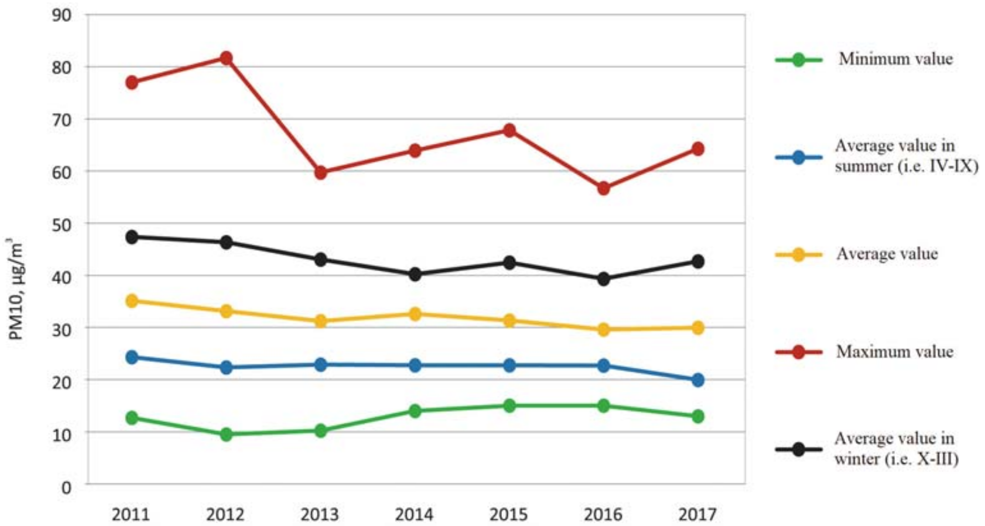

Fig. 1. The average PM10 dust concentrations calculated from the annual measurement series from all stations operating within the State Environmental Monitoring (SEM) in 2011–2017 (source: Chief Inspectorate of Environmental Protection (GIOŚ)/State Environmental Monitoring (SEM))

In some voivodships (corresponding to provinces), where concentrations of air pollutants exceed air quality standards, provincial assemblies have adopted additional legal regulations aimed at reducing emissions of pollutants into the air, so-called anti-smog resolutions. The resolutions introduce restrictions or prohibitions on the operation of boilers, stoves and fireplaces as well as the use of low-quality solid fuels in specific areas of voivodships (Wiech et al. 2018).

The great alternative to the use of fossil fuels is assigned to apply renewable energy resources including geothermal energy, the resources of which are available within many regions of Poland. Hydrogeothermal energy resources in this country are accumulated as groundwater in deep underground reservoirs in various stratigraphic units and at distinct depths in areas of the Polish Lowlands, the Carpathians as well as in some locations in the Sudety Mountains and Carpathian Foredeep. The most perspective area is connected with the Polish Lowlands where geothermal water resources are stored in Mesozoic aquifers, particularly in Lower Cretaceous and Lower Jurassic clastics rocks. In many areas of the Polish Lowlands utilization of geothermal waters with relatively high temperatures (even in excess of 100ºC) and high capacities (even 300 m^3/h) is real (Sowiżdżał 2018). In those cities where water parameters are not sufficient for their use for heating purposes, the possibility of applying heat pumps should be considered. Either way, the utilization of the geothermal potential of any given region in both heating systems (deep geothermal) and in individual heating (shallow geothermal) contributes to the reduction of a significant number of air pollutants and can be an excellent way to improve air quality in Polish cities.

The impact of air pollution on the environment is a particularly important issue not only because of the general prevalence of this phenomenon, the amount of emitted pollutants and its wide range (from local to global scale), but also due to the fact that these pollutants affect other components of the environment, including human's health.

Environmental aspect of geothermal energy utilization

Impact on the air quality

Generally, the impact of the geothermal energy sector on the condition of atmospheric air is considered highly positive. Geothermal energy, compared to conventional fuels, does not emit significant amounts of pollutants (including CO_2, SO_2, NO_x, particulate matter; Tab. 1) to the natural environment (Tomaszewska and Szczepański 2014). In the case of geothermal installations, potential emissions of gaseous substances are mainly related to the production of electricity in high temperature geothermal areas (e.g. Iceland, New Zealand and USA). Then, mainly carbon dioxide (CO_2) or hydrogen sulphide (H_2S) get into the air, and in some cases, also trace amounts of methane (CH_4), hydrogen (H_2), sulphur dioxide (SO_2), or ammonia (NH_3) (Geoelec 2013).

Due to the use of geothermal energy for space heating purposes in Poland, there is a noticeable improvement of the atmospheric air quality. This is confirmed by significant ecological effects attained by operating for around two decades Geothermal District Heating Plants in the Polish Lowlands or Podhale region. Also, it remains a particularly important issue as the problem of so-called low-emission is increasing constantly (Kaczmarczyk 2015) and, on the other hand, the preservation of natural environment is of great importance in Poland as well as worldwide. The limitation of emissions of gases such as carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), and particulate matter (PM10, PM2.5) accompanying the combustion of fossil fuels, is of particular matter especially in Podhale region, which is one of the most frequently visited tourist regions in Poland. According to the Geothermal District Heating Plant – Geotermia Podhalańska SA (GeoDH Podhale 2018), the average annual concentration of sulphur dioxide before the implementation of the geothermal project (i.e. 1994–1998) was equal to 32.6 μg/m³. Nowadays,

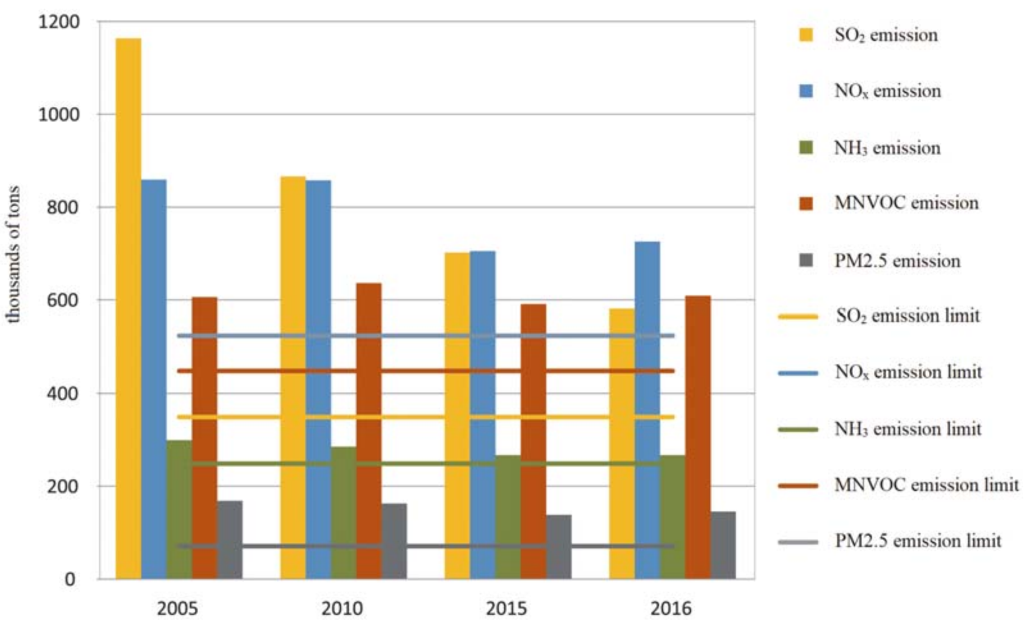

Fig. 2. The volume of SO_2, NO_x, NH_3, NMVOC and PM2.5 emissions on the background of levels to be achieved by 2030 as defined in the Directive on the reduction of national emissions of certain atmospheric pollutants (Wiech et al. 2018)

as the result of expanding the number of geothermal heat recipients, the concentration of SO_2 (Fig. 3) fluctuates between 8 and 13 μg/m^3 for the period of 2004–2016 (GeoDH Podhale 2018). In 2017, the amount of SO_2 measured by the Institute of Meteorology and Water Management – National Research Institute (abbr IMGW-PIB) in Zakopane was set as 11 μg/m^3 (Fig. 3). That data indicates a three-fold reduction in emissions of this substance to the atmosphere. Also, the emission of particulates matter trends downwards – the values were 54.3 μg/m^3 before, and 43.1 μg/m^3 after the implementation of the geothermal project, respectively (GeoDH Podhale 2018). The annual decline of CO_2 emission in 2017 totalled $41.7 \cdot 10^6$ kg (Fig. 4). As can be noticed, the use of geothermal energy in Podhale has allowed to reduce the amount of carbon dioxide emissions by over 530 thousand tons within 25 years (Fig. 4). The reduction of CO_2 emissions associated with the development of geothermal district heating in Podhale region during the aforementioned period is presented in the Fig. 4.

Other geothermal district heating plants operating in Poland have also achieved significant ecological effects, contributing to the improvement of the quality of the atmospheric air locally, as well as globally. Due to the lack of the latest data on the ecological effect achieved by these geothermal DH plants, the values of avoided emissions were calculated in relation to the geothermal heat produced in 2017 (Kępińska 2018). The calculations were based on emission rates published by The National Centre for Emissions Management (KOBiZE) (KOBiZE 2018)) for hard coal, as the main element in the present Polish energy mix. The results of the carried analysis – the average annual amounts of avoided pollutants emission for any geothermal installations located in the Polish Lowlands – are compiled in the form of a graph (Fig. 5).

Impact on the water and ground environments

The most significant impact on the water and ground environments takes place during the drilling phase (mostly as a result of a failure) and exploitation of the geothermal waters and energy (the possible effect of technological errors). At both stages, the possibility of a contamination of groundwater, rendering them to be unsuitable for use, is considered possible to occur (Nardini 2013). As a result of conducting the unsustainable exploitation of geothermal water deposits, the fluid can be reduced or even completely exhausted in the definite reservoir. At the same time, the

Table 1. Approximate pollutants emissions from various power plants; based on (Tester 2006)

Plant type	CO_2 [kg/MWh]	SO_2 [kg/MWh]	NO_x [kg/MWh]	Particulates [kg/MWh]
coal-fired	994	4.71	1.955	1.012
oil-fired	758	5.44	1.814	*not available*
gas-fired	550	0.0998	1.343	0.0635
hydrothermal *(liquid dominated)*	27.2	0.1588	0	0
hydrothermal *(dry steam dominated)*	40.3	0.000098	0.000458	negligible
hydrothermal *(closed-loop binary)*	0	0	0	*negligible*

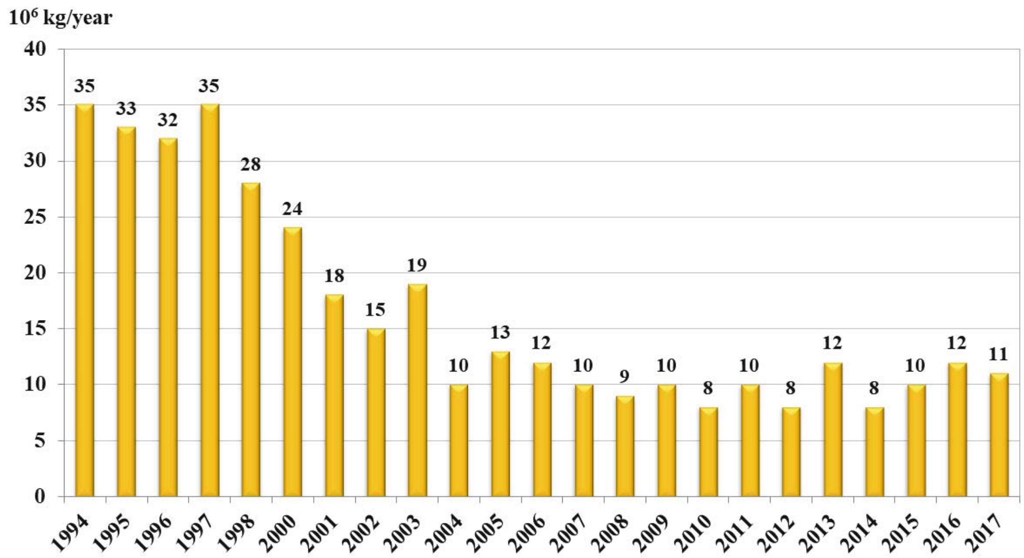

Fig. 3. Sulphur dioxide (SO_2) emissions for years 1994–2017 measured by the IMGW-PIB in Zakopane; based on (GeoDH Podhale 2018)

inherent peril associated with the issue of over-exploitation of geothermal water deposits is the problem of possible land deformations (e.g. subsidence, horizontal displacement of rock masses, etc.). The well-known instance of the area, where the significant subsidence (about 0.45 m·year^{-1}) was observed is the Wairakei geothermal field (New Zealand). It was classified as the result of over-exploitation of geothermal resources with simultaneous lack of injection of the spent water (Allis 1990, Allis et al. 2009). Another hazard resulting from an inappropriate exploitation of geothermal waters and energy is the possibility of cooling the geothermal water deposit and/or the rock formation down. What is more, the potential risk may be the so-called cold front breakthrough, i.e. the temperature of the reservoir comes down as the effect of re-injection of waste waters at much lower temperature (usually, it is the effect of an incorrectly designed installation). Considering the subject of injecting or discharging spent water into surface water, it is impossible to neglect the potential risk of influence on the mineralization, pH and temperature of formation waters.

According to the binding formal and legal regulations in Poland (Journal of Laws of 2018, item 2268, Journal of Laws of 2014, item 812), the injection of spent geothermal waters back into the rock formation is the best and the most optimal solution for its disposal. This aspect is particularly required when the saline water is extracted, particularly with the amount of total dissolved solids (TDS) above 3 g/L. On practical side, the terminal mineralization (TDS) of the geothermal water that requires re-injection is determined by the proper Regulation of the Minister of Environment (Journal of Laws of 2014, item 1800). Only the accomplishment of the terms specified in the aforementioned regulation, provides an opportunity to obtain the water-legal permit (Journal of Laws of 2018, item 2268) for discharging waste waters into the surface water. In addition to the TDS, chloride and sulphur contents, geothermal waters might contain boosted amounts of heavy metals and toxic microelements such as chromium, arsenic and boron that are considered definitely hazardous. Also, the temperature of discharged waters is of significant importance – too high can bring damages to the environment of inland fisheries (Journal

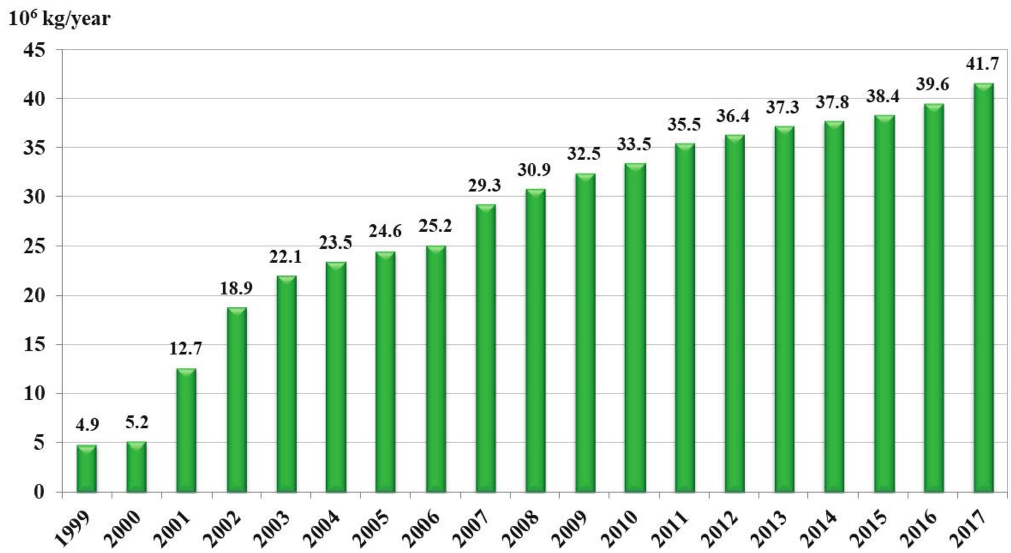

Fig. 4. Reduction of carbon dioxide (CO_2) emissions in Podhale region for years 1999–2017; based on (GeoDH Podhale 2018)

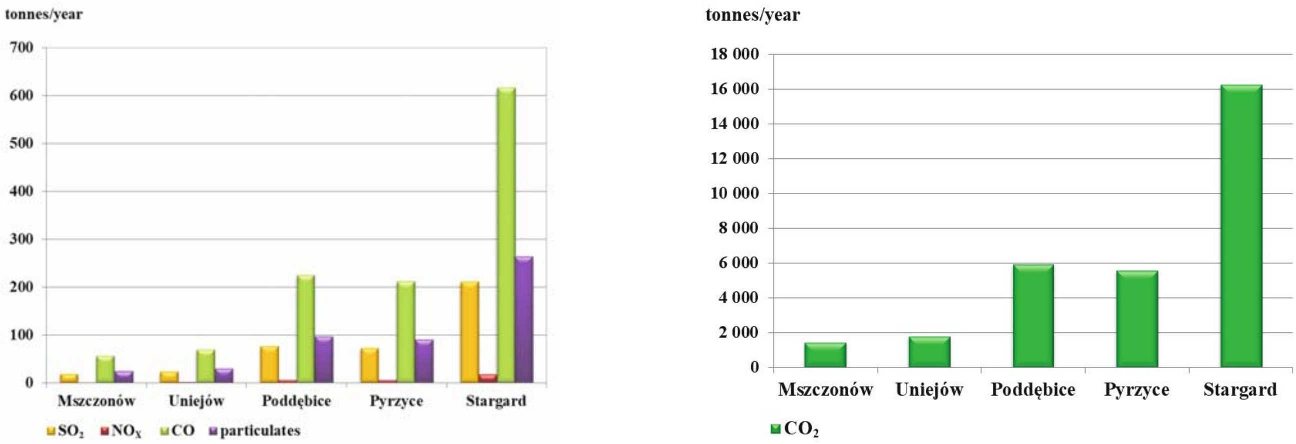

Fig. 5. The avoided emissions of different pollutants achieved by DH Plants within the Polish Lowlands in 2017 [tons·year^{-1}]; based on (KOBiZE 2018)

of Laws of 2016, item 71), which is often a factor precluding the entrepreneur from acquiring the permission for dropping waste water into the surface waters (e.g. rivers). The main objective of the Water Framework Directive 2000/60/EC is the protection of waters and the aquatic environment for future generations. Many geothermal plants in Poland spend chilled geothermal waters into the rivers. In legal conditions (Journal of Laws of 2018, item 2268), geothermal wastewater disposal is subject to restrictions and obliges the entity to conduct monitoring of the quality of discharged sewage. A surface water body SWB should be strictly protected so that it can be left in good quantitative and qualitative condition to future generations. The analysis of the results of water quality observations in the receiver (both before and below the outlet of discharged spent geothermal waters) brings the necessary data base to assess the current conditions of the river. The main conclusion is that the fullfilment of the water-legal permit conditions ensure the minimize impact of the environment and does not create excessive risk for the environmental objectives (Operacz 2018).

Impact on the landscape

Impact on the local landscape should be considered in the context of the temporary and long-term changes. The short--term impact on the local landscape is principally relevant to the drilling phase – the appearance of drilling rigs, equipment and machinery necessary for running work, as well as the infrastructure for the staff (Nardini 2013). However, this element is of short duration, that usually does not exceed half a year. As for the long-term changes, interference in the landscape is slightly larger. The magnitude of changes in the local landscape highly depends on the current status and use of the area, i.e. mainly if there is a need for drastic changes in the land use (e.g. deforestation) or the necessity to build transport infrastructure, etc. (Geoelec 2013). However, in contrast to exploratory drilling for fossil fuels purposes (mainly oil and gas sector), geothermal wells geared towards obtaining heat energy, are usually located in close vicinity of recipients – in areas of existing settlements, often with the high-density housing. This is an important factor associated with the limitation of energy losses on the way from the water intake, through the geothermal installation to the heat and hot water users, as well as the interference in the local landscape is usually smaller (Tester 2006).

Considering the possible impact on the local landscape, it is worth mentioning how the land development looks like within the area occupied by the geothermal installation together with the infrastructure (Tab. 2). In this case, geothermal power plants perform very positively – per 1 MW of the generated power, the geothermal power plant occupies 7 times less space than a nuclear plant, 20–50 times smaller area compared to a solar power plant and about 30–35 times smaller area than a coal-fired power plant (Tester 2006).

Impact on the acoustic climate

Another important issue of the analysis proceeded at the exploratory stage is the impact of drilling works on the local acoustic climate. Generally, deep hole drilling requires active and uninterrupted 24-hour work. Drilling facilities like compressors, power generators, pumping equipment and, above all, drilling rigs always generate some noise that can be disruptive to the local environment (Nardini 2013). What is important, the impact extent of the drilling rig in terms of acoustic, vibration and electromagnetic fields constitutes the important part of the detailed Environmental Impact Assessment. The stimulation of the well and trial pumping may be another source of noise. In this case, the scale of impact on the local acoustic climate is mainly dependent on the number of wells (Ogola 2005). In general, according to Nardini (2013), the noise level ranges from 45 to 120 dB and decreases with the distance away from the place of work. The average noise levels generated by the devices were collected and presented in Table 3. At this point it is worth emphasizing that the average noise level in the urban agglomeration is about 70–85 dB (DiPippo 2005), which indicates a small acoustic nuisance of any conducted drilling works.

Table 2. Comparison of areas occupied by particular types of power plants; based on (Tester 2006)

Technology	Power	Land use	
	[MW]	[m^2/MW]	[m^2/MWh]
Geothermal flash plant *(excluding wells)*	110	1,260	160
Geothermal flash plant *(including wells, pipes, etc.)*	56	7,460	900
Geothermal binary plant *(excluding wells)*	20	1,415	170
Coal plant *(including strip mining)*	2,258	40,000	5,700
Nuclear plant *(plant site only)*	670	10,000	1,200
Solar-thermal plant *(Mojave Desert, USA)*	47	28,000	3,200
Solar PV plant *(Southwestern USA)*	10	66,000	7,500

When considering the stage of operation of a geothermal installation, devices such as transformer, cooling tower (especially cooling fans) and the power plant itself, might generate some level of rather non-arduous noise. In this instance, the average noise level ranges from 55–70 dB (Nardini 2013), so it is akin to that one encountered in an average urban area.

Therapeutic and recreational application of geothermal water

The history of geothermal water utilization in Poland dates back to the Middle Ages and was associated with the natural symptoms of hot water outflows. In very old health resorts, which include Lądek Zdrój, Cieplice Śląskie Zdrój, and Iwonicz Zdrój, it is not possible to determine the exact commencement date of natural hot water usage. This is due not only to the distant time, but mainly to the loss of all documents as a result of wars, fires and other cataclysms. The first written mentions of the sources in Lądek Zdrój come from the beginning of the 17th century, but refer to the events of the first half of the 13th century and the Mongol invasion in 1241 during which, according to reports, the house was destroyed by a warm spring (Kiełczawa 2018), named later (in 1498) the sanctuary of St. Jerzy (Lądek Zdrój, 2018). At the end of the 16th century, the first medical text on healing properties of local waters appeared. In the following years, new sources were discovered, and soon bathing facilities were built. In 1765, Prussian King Fryderyk II used the warm waters, and a dozen years later (in 1790) Lądek was visited by Johann Wolfgang Goethe (Kiełczawa 2018).

The advantages of healing, balneological and recreational values of geothermal waters are being noticed today, too. In therapeutic treatments, under the supervision of health resort doctors, these waters are currently used in 10 localities: Rabka Zdrój, Ustroń, Lądek Zdrój, Cieplice Śląskie Zdrój, Konstancin, Duszniki Zdrój, Ciechocinek, Iwonicz Zdrój, Marusza near Grudziądz, and Uniejów. According to Gutenbrunner and Hildebrandt (1998), water can be used for medicinal purposes if it naturally contains a minimum amount of at least one of the components. In the Polish regulations (Journal of Laws of 2011 No. 85, item 466), if groundwater is not contaminated and has natural variations in physical and chemical parameters and contains at least one specific component (pharmaco-dynamic factors, Tab. 4) and also has a temperature above 20ºC, it is then considered to be geothermal therapeutic water (Journal of Laws of 2017, item 2126).

The utilization of geothermal water in Poland for recreational purposes is also prevalent. The system of cascade application of geothermal waters and energy, which most often include energy recovery for heating purposes and the use of balneological potential of waters in recreational facilities, becomes more and more common. Such solutions are used in installations built strictly for heating purposes, in particular in the geothermal system of PEC Geotermia Podhalańska SA, in PEC Geotermia Mazowiecka SA, Geotermia Uniejów, and Geotermia Poddębice, but also installations specially created for supplying recreational facilities with heat and geothermal water. At the end of 2018 there were at least 14 recreational facilities based on geothermal waters in Poland: two facilities in Szaflary (Termy Szaflary, Gorący Potok) and Zakopane

Table 3. Indicative noise levels generated on a geothermal; based on (Ogola 2005)

Operation	Noise level [dB]
air drilling	85–120
mud drilling	80
discharging wells vertically	up to 120
normal well testing through silencers	70–110
diesel engines	45–55
heavy machinery	up to 90

Table 4. Therapeutic classification of natural groundwater in Poland; according to (Journal of Laws of 2017, item 2126)

Total dissolved solids (TDS)	Temperature [°C]	Pharmaco-dynamic factors	Water type
Above 1 $g \cdot l^{-1}$ (mineral water) Below 1 $g \cdot l^{-1}$ (slightly mineralized)	Above 20 (thermal water) Below 20 (cold water)	2 mg $F^{-} \cdot l^{-1}$	Fluoride
		1 mg $I^{-} \cdot l^{-1}$	Iodated
		1 mg $S(II) \cdot l^{-1}$	Sulphuric
		70 mg $H_2SiO_3 \cdot l^{-1}$	Silica
		10 mg $Fe(II) \cdot l^{-1}$	Ironic
		74 $Bq \cdot l^{-1}$	Radon or radioactive
		250 $mg \cdot l^{-1}$ free CO_2	Carbonate
		1000 $mg \cdot l^{-1}$free CO_2	CO_2-rich, carbonized

(Aqua Park Zakopane, Polana Szymoszkowa), Bukowina Tatrzańska, Białka Tatrzańska, Chochołów, Kleszczów, Uniejów, Mszczonów, Poznań, Tanów Podgórne, Poddębice, and Lidzbark Warmiński.

Warm geothermal waters for centuries have been a symbol of the source of life and longevity, as well as physical and emotional strength. The possibility of using recreational and balneological treatments based on natural geothermal waters is perceived as an effective relaxation method, relaxing muscles and improving the spiritual and emotional state. Maintaining a good look and the resulting attractiveness is one of the significant aspirations of many people. For users of swimming pools, frequent supplements to the treatment are home baths with the addition of medicinal salts and/or cosmetics created on the basis of curative and thermal waters. The line of cosmetics based on geothermal waters widely known on the Polish market includes *Iwostin*, *Termy Uniejów*, *Uzdrowisko Rabka*, and *Termissa*. Further research aimed at obtaining valuable geothermal water concentrates, with therapeutic and balneological properties is also being carried out (Tomaszewska 2015, Tomaszewska 2018, Tomaszewska et al. 2018a, 2018b, Tyszer and Tomaszewska 2019). It is therefore justified to combine pro-health use of geothermal waters in recreation and cosmetology as an effective solution in "improving living conditions".

National support for increasing the use of geothermal energy as an ecological energy source

Currently, the recognition of geothermal water and energy, as one of the Polish Government's priorities in national energy and economic development, has translated into the implementation of a financial backing and/or co-funding programs for particular geothermal investments, by the Ministry of the Environment (Kępińska 2018). The financial support for the Polish geothermal energy sector is provided mainly by the National Fund for Environmental Protection and Water Management (abbr NEEP&WM), that is the pillar of the Polish system for funding many distinctive projects aimed at the effective and efficient environmental protection. In the case of geothermal energy, the main goal is set as the utilization of geothermal energy resources for heating purposes and generation of electricity, for the period from 2014 to 2025. Therefore, three relevant programs are available for entrepreneurs in the case of geothermal energy sector, namely (NEEP&WM 2018): *Geology and Mining – Part 1) Recognition of the geological structure of the country and management of mineral deposits and groundwater resources*; *Improvement of Air Quality – Part 1) Energy use of geothermal resources; Operational Program Infrastructure and Environment – Activity 1.1. Supporting the production and distribution of energy from renewable sources* (co-financed from the Cohesion Fund). These priority programs of the NEEP&WM fit into the national energy policy that is concentrated on increasing the share of renewable enrgy sources in the energy mix and promote green energy, including geothermal resources, simultaneously, reducing or even fully covering the costs of potential geothermal investment (NEEP&WM 2018). The rational effect of the programs implemented by NEEP&WM is the implementation of new geothermal investments and increase in the efficiency of currently operating installations in Poland. So far, several applications have received positive opinion and some of them (inter alia towns of Szaflary, Lądek-Zdrój, Sochaczew, Sieradz, Koło, and Tomaszów Mazowiecki) have signed agreements with NEEP&WM, others are still waiting for the decision of the Main Geologist of the Country (Sowiżdżał et al. 2017). As a result, the increasing number of geothermal installations within the country will bring many positive environmental as well as social effects in the future.

Conclusion

Geothermal energy, due to a number of benefits entailed by its utilization, is said to be a very valuable natural resource. Everywhere, where existing resources of geothermal waters and energy enable its effective use, it should be used for various purposes – especially for heating, but also if possible for other applications, e.g. recreational or balneotherapeutic. The key environmental aspect of the development of geothermal resources, especially in the context of the necessity to counter the phenomenon of low emissions in Poland, is the positive impact on the quality of atmospheric air. The utilization of geothermal energy does not cause the significant emission of pollutants into the natural environment, thus contributing to the improvement of air quality. This element is notably important due to the fact that high concentrations of particulate matter PM10 and PM2.5 remain the most important problem of air quality in Poland. These overruns usually occur in the winter period and are mainly related to the dust emission coming from the individual heating of buildings.

In this paper, the impact of geothermal energy on the natural environment was also considered in the aspect of the influence on the water and soil environments, the landscape and the acoustic climate. In fact, all environmental hazards resulting from the operation of a geothermal installation are usually limited to failure states or technological errors, and are rather kind of short duration. Moreover, for a correctly designed and efficiently working installation, positive environmental effects are visible in all analyzed aspects.

The use of geothermal waters for therapeutic, balneological and recreational purposes also brings a number of positive social and health results. Medical properties of water have been well-known and commonly used for many centuries. As proved, the possibility of using recreational and/or balneological treatments based on natural geothermal waters positively influences the human body and is perceived as an effective relaxation method.

Summarizing the considerations undertaken throughout this paper, it should be clearly stated that the use of geothermal waters and energy can significantly improve the living conditions in any given region. The best proof for that are several geothermal centers currently operating in Poland, including district heating plants as well as recreation and balneotherapy centers. The number of positive aspects, both environmental and social, originated in the utilization of geothermal waters and energy have a direct impact on the quality of living conditions of citizens. It is visible primarily in improvement of the local air quality, but also in the growth in accessibility to various products based on geothermal water (pools, balneological resorts, health services, cosmetics, etc.).

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Czy wody geotermalne oraz ich energia mogą poprawiać warunki życia lokalnej społeczności? Efekty środowiskowe z Polski

Streszczenie: Problem zanieczyszczenia powietrza, wynikający w dużej mierze z wykorzystania paliw kopalnych do celów energetycznych, jest jednym z najpoważniejszych zagrożeń środowiskowych w wielu miastach Polski, ale również poza nimi w mniejszych miejscowościach. Ilość zanieczyszczeń emitowanych do atmosfery przekłada się wprost na warunki życia mieszkańców. Wykorzystanie energii geotermalnej, która jest odnawialnym i ekologicznym źródłem energii, przynosi zauważalną poprawę jakości powietrza atmosferycznego, o czym świadczą znaczące efekty ekologiczne osiągane przez działające ciepłownie geotermalne. W pracy przedstawiono wyniki kompleksowych rozważań dotyczących oceny skutków wykorzystania wody i energii geotermalnej w Polsce. Omówiono zagadnienia związane z realizacją prac poszukiwawczych mających na celu pozyskanie zasobów wód geotermalnych, a także aspekty środowiskowe wykorzystania wód geotermalnych i energii. Podjęte rozważania ukierunkowane były na ocenę, czy wykorzystanie takiego rodzaju odnawialnych źródeł energii może mieć wpływ na poprawę warunków życia lokalnej społeczności.