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The impact of pollution on the mental health of the population

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
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ABSTRACT

This paper analyzes the relationship between pollution of the natural environment and the population's mental health, based on the example of three urban agglomerations: Gdańsk, Poznań, and Katowice. The following factors were analyzed: air quality, the quality of water from the municipal waterworks, data concerning social pathologies, number of private psychological, psychotherapeutic, and psychiatric practices, as well as statistics concerning psychiatric healthcare in the Pomeranian, Greater Poland, and Silesian voivodships in 2011. Based on the collected data, presented in a descriptive manner, a hypothesis was drawn that natural environment pollutions may influence the mental health of the population. This conclusion was drawn from the fact that worse air quality in Katowice correlates to a higher percentage of social pathologies and a higher demand for psychiatric healthcare than in Poznań or Gdańsk.

Keywords: environmental pollution; mental health; ecological psychiatry.

Introduction

Natural environment pollution influences, to a large extent, the degradation of Earth's biosphere; it also has a significant impact on the broadly understood public health. Taking into account the inextricable connection of human beings to the environment, it should be concluded that the environment strongly influences human health. Pollution is one of the natural environment factors that most influence human health and occur in all elements of the environment, i.e.: water, soil, along with noise or light pollution. Environmental toxins have a negative impact on the physical health of the population, but it can

also be assumed that they have similar influence on their mental health. It is widely established in the public and environmental health literatures that primarily exposure to air pollution is hazardous to human health.

In the analyzed period – the year 2011 – more and more social pathologies (acts of violence, murder, alcoholism, and others) were related to an increase of concentration of pollutants in the air and water and adverse weather conditions [1]. In scientific literature [2, 3] papers suggesting a cause-and-effect relationship between the high suicide rates and ecological threat in the analyzed area were published. Bandiera et al. [4]

also point to a strong dependency between passive smoking and risk of depression, and Wueve et al. [5] the decrease in cognitive intelligence in a group of elderly women. Lundberg [6] correlates the following variables: increase in air pollutants and a number of psychiatric emergency calls and psychiatric admissions, indicating a statistically significant relationship.

In this paper, an analysis is carried out, covering the following parameters for urban agglomerations of Gdańsk, Poznań, and Katowice in 2011:

- › atmospheric air quality,
- › tap water quality,
- › social pathology statistics,
- › numerical data relating to private psychiatric practices, private psychotherapeutic and psychological offices.

Moreover, statistics concerning psychiatric healthcare in the Pomeranian, Greater Poland, and Silesian voivodships were considered.

Aim

The general objective of the study was to find a relationship between the presence of environmental pollution and the mental health status of the population, as a response to the unsatisfactory level of current knowledge in the field of ecopsychiatry, which poses a threat to public health in the face of constantly progressing degradation of the natural environment.

The detailed objectives were formulated in the form of the following questions:

- › Do environmental pollution affect the mental health of the population?
- › Does the level of toxins in atmospheric air correlate with a higher percentage of recorded social pathologies?
- › Is there a connection between the demand for private and state psychiatric health care and the quality of atmospheric air?

Materials and Methods

The object of research were data concerning populations of urban agglomerations of Gdańsk, Poznań, and Katowice in 2011. Those cities were selected due to differences in environmental conditions (stemming from their geographical situation) and the degree of industrialization. The research material were numerical data from

2011, concerning selected natural environment pollution indicators and the mental health of the population obtained from the following databases: Voivodship Inspectorates for Environmental Protection (WIOŚ), Voivodship Sanitary and Epidemiological Stations (WSSE), Municipal Police Stations, Centre of Health Information Systems (CSIOZ), Central Electronic Register and Information on Economic Activity (CEIDG) and Local Databank. Furthermore, information from Polish Psychological Association and Municipal Police Stations were obtained by electronic correspondence and personal interviews. The most relevant environment pollution indicators, influencing the entire population of abovementioned cities, was air quality (monitored by the WIOŚ), as well as physical and chemical parameters of tap water (on the basis of results of review monitoring carried out by the WSSE). The mental health of the population was evaluated based on statistics provided by: Municipal Police Stations, CSIOZ, CEIDG, and the Local Databank. The paper presents only selected, most important results that have the most significant impact on the result of research conducted.

The air quality was evaluated through an analysis of automatic pollution measurements. Besides the visible differences in concentration of the analyzed substances for the studied urban agglomeration, differences are also marked in the scope of measurements taken and their publication: for Gdańsk, only 5 parameters were taken, for Poznań – 21, and for Katowice – 23. An analysis of that problem in this article was therefore limited to 5 parameters. The tap water quality evaluation was obtained from Voivodship Sanitary and Epidemiological Stations which conducted a control and review monitoring. The number of parameters taken was 36 for Gdańsk, 60 for Poznań, and as many as 71 for Katowice, which in turn influenced the final scope of the research material.

Since mental health is a very complex issue, difficult to analyze, a multidimensional approach was adopted. One of the studied markers were social pathologies (deviations). Information concerning the number of social pathologies occurring: homicide, suicide (resulting in death), domestic violence, fights or battery (Art. 158 and 159 of the Polish Penal Code) for 2011 were provided by Municipal Police Stations in Gdańsk,

Poznań and Katowice. The absence of data concerning the number of suicides in the city of Katowice for 2011 was justified by the fact that very often, suicide was not included in the statistical system due to protocol [7]. As concerns domestic violence, data was only collected in relation to persons (not exclusively women) who have decided to report a crime, which resulted in an actual initiation of penal procedure. Statistics did not include the so-called "blue cards" (Polish Domestic Violence Police Intervention Protocols) which do not necessarily entail the initiation of pre-trial proceedings.

The assessment of mental health of the population was also carried out on the basis of data obtained from the Centre of Health Information Systems concerning the number of private practices ran by psychiatrists in Poznań, Gdańsk, and Katowice.

In the same manner, data concerning private psychological and psychotherapeutic offices in the studied urban agglomerations was generated from the resources of the Central Electronic Register and Information on Economic Activity.

Data concerning psychiatric care were complemented by statistics from the Central Statistical Office's Local Databank [8]. Although they concern entire voivodships, and not specific cities, they may contribute to our understanding of

the problem, as each of the discussed agglomerations is the biggest city in a given region.

Statistical analysis methods

Numerical results were expressed in arithmetical mean, standard deviations, and coefficients calculated per number of inhabitants. Due to the limited amount of numerical data and their pre-processing (absence of results of single measurements), it was not possible to carry out statistical tests. Therefore, results are presented in a descriptive manner, using tables.

Results and Discussion

Air quality

Table 1 presents annual average pollutant concentrations in the analyzed urban agglomerations. The highest concentration of sulfur dioxide (SO₂) in 2011 was noted in Katowice, and the lowest in Poznań, with only slightly higher concentration in Gdańsk. In concerns nitrogen dioxide concentration (NO₂), it was also highest in Katowice, and lowest in Gdańsk. Average carbon oxide (CO) concentrations were identical for Gdańsk and Poznań and highest for Katowice. Both the concentrations of ozone (O₃) and particular matter (PM 10) are similar: the highest annual average concentra-

Table 1. Annual average and standard deviation of concentrations of selected air pollutants and physical and chemical parameters of tap water in urban agglomerations of Gdańsk, Poznań and Katowice [9–14]

Substance	City	Gdańsk	Poznań	Katowice
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
SO ₂ [$\mu\text{g}/\text{m}^3$]		5.96 ± 2.31	3.84 ± 2.46	15.92 ± 7.96
NO ₂ [$\mu\text{g}/\text{m}^3$]		18.92 ± 3.57	24.79 ± 7.14	47.96 ± 16.83
CO [mg/m^3]		0.36 ± 0.13	0.36 ± 0.11	2.10 ± 1.22
O ₃ [$\mu\text{g}/\text{m}^3$]		40.9 ± 16.48	45.44 ± 15.26	110.83 ± 36.23
Particular matter PM 10 [$\mu\text{g}/\text{m}^3$]		28.82 ± 5.55	39.42 ± 18.95	58.92 ± 26.68
Selected physical and chemical parameters of tap water in Gdańsk, Poznań and Katowice				
Nitrates (NO ₃) [mg/l]		2.10 ± 1.98	n/o	3.76 ± 1.08
Manganese (Mn) [$\mu\text{g}/\text{l}$]		5.20 ± 9.63	8.42 ± 7.80	5.87 ± 6.01
Ferrum (Fe) [$\mu\text{g}/\text{l}$]		44.25 ± 47.0	41.67 ± 55.04	104.75 ± 60.80
Fluorides (F) [mg/l]		0.37 ± 0.46	0.22 ± 0.02	0.09 ± 0.04
Chlorides (Cl) [mg/l]		31.7 ± 34.38	42.39 ± 1.59	9.25 ± 1.08
Sulfides (SO ₄) [mg/l]		41.15 ± 27.20	90.63 ± 12.31	25.51 ± 2.19
Boron (B) [mg/l]		0.15 ± 0.26	0.07 ± 0.03	nd
Aluminium (Al) [$\mu\text{g}/\text{l}$]		4.97 ± 8.81	n/o	26.45 ± 35.12
Nickel (Ni) [$\mu\text{g}/\text{l}$]		1.13 ± 1.10	3.58 ± 1.25	n/o
Chromium (Cr) [$\mu\text{g}/\text{l}$]		2.95 ± 2.10	1.29 ± 1.02	n/o
Copper (Cu) [mg/l]		0.04 ± 0.11	0.005 ± 0.01	n/o
Arsenic (As) [$\mu\text{g}/\text{l}$]		0.39 ± 0.62	0.65 ± 0.80	nd
Trihalomethanes THM [$\mu\text{g}/\text{l}$]		2.75 ± 5.20	29.33 ± 7.31	13.94 ± 6.75

n/o – indeterminable, nd – no data

tion of those pollutants were observed in Katowice, and lowest in Gdańsk. Both parameters were slightly higher in Poznań. Concentrations of all 5 analyzed parameters were highest in Katowice.

Quality of tap water

Table 1 summarizes selected physical and chemical parameters of water from public waterworks in the analyzed cities. The highest concentration of nitrates (NO₃) in the studied period was noted in Gdańsk, and lowest in Katowice. In Poznań, the level of that substance was indeterminable. Annual average concentration of manganese (Mn) was highest in Poznań, lowest in Gdańsk, with slightly higher concentration in Katowice. The level of iron in tap water was highest in Katowice and lowest in Poznań. The highest concentration of fluorides (F) was determined in the city of Gdańsk, lowest in Katowice, and slightly higher in Poznań. Concentrations of chlorides (Cl) and sulfides (SO₄) were highest in Poznań, lowest in Katowice, and in Gdańsk, their level was a little higher than in Katowice. As concerns concentrations of boron (B), the lowest was observed in Poznań, higher in Gdańsk, and in Katowice, the level of that substance was not measured. The level of aluminum (Al) was indeterminable in Poznań, high in Katowice, and lower in Gdańsk. 3 other parameters – nickel (Ni), chromium (Cr), and copper (Cu), were indeterminable in Katowice. The nickel concentration

was lower in Gdańsk than in Poznań, as opposed to chromium, whose level was lower in the water in Poznań than in Gdańsk, similarly to the levels of copper for Poznań and slightly higher level for Gdańsk. The concentration of arsenic (As) was not measured in Katowice, and in Poznań, it was higher than in Gdańsk. The sum of trihalomethanes (Σ THM) was determined as lowest in Gdańsk, highest in Poznań, and slightly lower in Katowice.

Social pathologies

Table 2 shows the data concerning selected social pathologies in the analyzed cities in 2011. In police databases, 11 homicide cases were noted in Katowice and Gdańsk, with 10 in Poznań. Calculated per 10 thousand inhabitants, this indicator is highest in Katowice, lowest in Poznań, and slightly higher in Gdańsk. As regards suicide, we do not dispose of any statistics concerning Katowice; in Gdańsk, the indicator is higher than in Poznań, despite the fact that the overall number of events was slightly higher in the capital of Greater Poland than in the main metropolis of the Pomerania.

Cases of domestic violence were reported most often in Gdańsk; their rate, per 10 thousand persons, was also highest. The lowest number of reports was noted by the Katowice police, although when calculated per the number of inhabitants, the rate is higher than in Poznań. In 2011, brawls and battery occurred most often in Poznań, least

Table 2. Selected social pathologies, number of private psychiatric practices, number of private psychological and psychotherapeutic in Gdańsk, Poznań and Katowice in 2011 [7, 8, 15, 16, 18]

		City		
		Gdańsk	Poznań	Katowice
		Total number	Total number	Total number
		Rate per 10 thousand inhabitants	Rate per 10 thousand inhabitants	Rate per 10 thousand inhabitants
Selected social pathologies	Homicide	11	10	11
		0.24	0.18	0.36
	Suicide (resulting in death)	37	38	nd
		0.80	0.69	nd
	Domestic violence	247	175	105
	5.36	3.17	3.41	
	Brawl, battery (art. 158 and 159 of the Polish Penal Code)	85	153	120
		1.85	2.77	3.89
Number of private psychiatric practices	Number of practices	64	68	50
		1.39	1.23	1.62
Number of private psychological and psychotherapeutic	Psychological offices	138	213	70
		3.00	3.86	2.27
	Psychotherapeutic offices	66	65	42
		1.43	1.18	1.36

nd – no data

often in Gdańsk, and slightly more often in Katowice. Considering the size of the population, the lowest rate was also noted in Gdańsk, the highest in Katowice, and slightly lower in Poznań.

The overall number of offenses per 1000 Polish citizens in 2011 (rate for Poland – 3036) indicates that the highest level of crime was noted in the western provinces, and the lowest – in the eastern part of the country. Among the analyzed regions of Poland, the highest number of offenses per 1000 inhabitants was noted in the Silesian voivodship (3712), the lowest – in the Greater Poland voivodship (2965), and slightly higher in the Pomeranian province (3325).

Private psychiatric practices

Table 2 presents the data concerning private practices ran by psychiatrists in 2011 in the studied urban agglomerations. The number of practices in that period was lowest in Katowice, highest in Poznań, and minimally lower in Gdańsk. Per 10 thousand inhabitants, the rate was lowest in Poznań and highest in Katowice.

Private psychological and psychotherapeutic offices

Table 2 contains the data obtained from the Central Electronic Register and Information on Economic Activity, concerning the number of private psychological and psychiatric practices in the analyzed urban agglomerations. Psychological offices are most numerous (both in terms of their overall number and per number of inhabitants) in Poznań, least numerous in Katowice, and slightly more in Gdańsk.

The number of psychotherapeutic offices was highest in Gdańsk, minimally lower in Poznań, and lowest in Katowice; an taking into account

the size of population, the rate per 10 thousand inhabitants was also highest in Gdańsk, lower in Katowice, and lowest in Poznań.

Psychiatric healthcare

Table 3 shows the data concerning psychiatric healthcare in Pomeranian, Greater Poland, and Silesian voivodships. The overall number of beds in psychiatric hospitals and their departments is highest in the Silesian voivodship, lowest in Pomeranian, and slightly higher in the Greater Poland province. Per 100 thousand inhabitants, the highest bed rate is also in Silesia, minimally lower in Pomerania, and lowest in the Greater Poland. The number of persons treated in psychiatric hospitals in 2011 was highest (also per number of inhabitants) in the Greater Poland voivodship, slightly lower in the Silesian province, and lowest in Pomerania. Persons addicted to alcohol (registered in clinics) in 2011 were most numerous in Silesia, least numerous in the Greater Poland, and slightly more numerous in Pomerania. The number of people with mental and behavioral disorders registered in clinics, and their distribution, is identical – their number was highest in the Silesian province, the lowest in Greater Poland, and slightly higher in Pomerania.

Conclusions

The analysis of the data presented above did not provide conclusive evidence as to the impact of the natural environment pollution on the mental health of the population.

Studying the numerical data obtained from WIOŚ [9–11], we have observed that the quality of atmospheric air is decidedly worst in Katowice, where average concentrations of all 5 hazardous

Table 3. Statistics concerning psychiatric healthcare in Pomeranian, Greater Poland and Silesian voivodships [19]

	Pomeranian	Greater Poland	Silesian
	Total	Total	Total
	Rate per 10 thousand inhabitants	Rate per 10 thousand inhabitants	Rate per 10 thousand inhabitants
Beds in psychiatric hospitals and departments	1125	1457	2297
	0.49	0.42	0.50
Patients in psychiatric hospitals	10145	22410	21550
	4.44	6.50	4.66
Persons addicted to alcohol (registered in clinics for the mentally disordered)	73567	66279	174920
	32.22	19.22	37.86
Mental and behavioral disorders (without addictions) –registered in clinics	63408	54876	146259
	27.77	15.92	31.65

substances were significantly higher than in other analyzed cities.

On the other hand, in the case of water, no significant differences are visible in water quality of each city. In Katowice, we lack data concerning certain parameters, and some of them is indeterminable. It should be noted that an analysis of all results provided in WSSE reports concerning exceeding the acceptable limits of parameter values (in accordance with – applicable then – Regulation of the Minister of Health of 29 March 2007 (Journal of Laws no. 61, item 417, as amended) has shown that it occurred only three times in 2011: in Gdańsk (1 x ammonium ion and 1 x fluorides) and in Poznań (1 x turbidity). In Katowice, deviation from the accepted norms was found in none of the samples. This may suggest that water in Gdańsk should, perhaps, be classified as the worst among the studied cities. The abovementioned missing markers of certain parameters as well as differences in measurement methodology indicate, however, that such conclusions should not be drawn too hastily.

Information provided by Municipal Police Stations [7, 15, 16] show that in two cases out of four, the highest social pathology rate (per 10 thousand inhabitants) occurred in Katowice (homicide, brawls, battery). It correlates with the situation in the entire country, as, according to the Minister of Interior [62], the threat of crime was, in 2011, higher in Silesia than in the remaining regions of Poland.

A confirmation of the results obtained may be found e.g. in a publication by Mordawa [22], who, in his thorough analyses, shows that in the period from 2008 to 2011, the highest crime level among the analyzed agglomerations was noted in the Katowice region (40.3 thousand offenses), slightly lower in Pomerania (37.8 thousand), and lowest in Poznań (27 thousand).

Katowice is also the leading centre as concerns the number of private psychiatric practices (per 10 thousand inhabitants). However, data obtained from CSIOZ [8] are imprecise and do not allow to accurately determine the number of offices. Physician Chambers do not maintain records concerning those offices, and therefore the statistics are unreliable. Similar problems arose with psychological and psychotherapeutic offices. Acting in accordance with the Act of 8 June 2001 on the profession of psychologist and the profes-

sional self-government of psychologists (Journal of Laws no. 73, item 763), we tried to determine the exact number of psychological practices on the basis of the list of psychologists authorized to practice that should be held by the Council of the Regional Chamber of Psychologists. According to information provided by Polish Psychological Society, however, it is a dead letter. There is no self-government of psychologists, Regional Chambers existed only in residual form (practically only in Podlaskie region) and there was no entity holding a register of psychologists for the studied urban agglomerations.

Figures generated from the CEIDG [18] indicate that the highest number of psychological offices (per number of inhabitants) functioned in Poznań, and psychotherapeutic – in Gdańsk. The data, however, is incomplete, as the PKD code (Polish Classification of Activity) is the same for several medical professions. In view of the above, the generated numerical data reflect reality only to some extent. They may, however, serve as indicative material.

In the process of completion of data concerning psychiatric healthcare, we intended to compare statistics for psychiatric clinics located in the analyzed urban agglomerations, in terms of e.g.: percentage of bed use or the number of patients classified in each ICD-10 diagnosis groups. This information (complete) was provided only by Poznań. The institution from Gdańsk sent only a small fragment of necessary statistics, whereas the center in Katowice (despite numerous requests) did not agree to cooperate with us. Therefore, research plans were modified and limited to statistics from Statistical Office's Database (the only data publicly available) [19]. When analyzing data obtained from that database, it is easy to notice that in three categories out of four, the Silesian voivodship was in the lead: it had the highest number of beds in psychiatric hospitals, and clinics registered the highest number of alcohol-addicted persons and patients with mental and behavioral disorders. Only the number of patients of psychiatric hospitals was slightly higher in the Greater Poland region.

Information and conclusions demonstrated above, concerning mental health of the discussed voivodships and agglomerations, matched the results of research by Langiewicz and Pasiorowska [27], who found that in 2006, the rate of "under sec-

tion" cases per 10 thousand inhabitants was highest in the Silesian voivodship (4.1), slightly lower in Pomerania (4.0), and lowest in Greater Poland (2.7).

The results presented above may lead to a hypothesis that pollution of the environment may influence mental health of the population. Considering the fact that in Katowice in 2011, the air quality was worst among the analyzed cities, the number of social pathologies was highest, as was the demand for psychiatric healthcare (private practices, mental health clinic), there is a possible dependence of these variables. It is, however, no more than a conjecture. Due to different methodologies and larger extent of research cited above, one should proceed carefully when correlating the results with those we obtained. Nonetheless, it should be noted that in Katowice, where the air is most polluted, homicide, brawls, and battery occur more frequently than in other cities. It may also stem from the unemployment problem against which that area struggled at the time.

If we obtained complete statistical data on suicide, the relationship between the condition of the environment might turn out to be the same as in the case of research conducted by Korean scientists [24]: Changsoo et al. demonstrated a visible correlation between a transient PM concentration in air with a higher risk of suicide, especially in persons suffering from cardiovascular diseases. Considering the fact that in Katowice, PM 10 pollution is decidedly higher than in Poznań or Gdańsk, one may assume that police statistics concerning suicide may also be higher than in other cities.

Allen et al. [25] conducted research that may, to some extent, explain the higher number of persons registered in Silesian mental health clinics. The authors have proven that mice that grow breathing polluted urban air are more impatient than mice breathing the air purified by filters. When they reached maturity, animals from group 1 expected immediate gratification, whereas those which breathed clean air did not. This study is noteworthy, as mice were exposed in early periods of life, but consequences of that exposure were observed in adulthood. Mice exposed to toxins after puberty did not demonstrate any change in their behavior, which may suggest that the damage to the growing brain was critical for the observed behavioral effect. The inability to wait and acting on impulses is always related to impairment of cognitive func-

tions and behavioral disorders, including addictions. Hence the assumption that a similar mechanism may occur in the population of Silesians who, exposed to air of poor quality, need help treating alcohol addictions or mental and behavioral disorders more often than the inhabitants of Greater Poland or Pomerania. Hypotheses formulated in this paper are confirmed in scientific research presented above.

Victoria Sass et al. [26] conducted research that was the first study of its kind to utilize longitudinal, nationally representative panel data from the United States to assess the relationship between exposure to air pollution and reports of psychological distress. Using annual-average measures of air pollution in respondents' census blocks of residence we find that over the period 1999–2011 particulate matter 2.5 is significantly associated with increased psychological distress; this association remains even after controlling for a robust set of demographic, socioeconomic, and health-related covariates. This study suggests that public health efforts to reduce the personal and societal costs of mental illness should consider addressing not only individual characteristics and factors in the social environment, but also underexplored facets of the physical environment such as air pollution.

As the number of factors influencing human organism is overwhelming, it is extremely difficult to prove that one of them (drinking water/air/soil, etc.) determines one specific illness. It is easier to prove in the case of physical health, where somatic symptoms are more pronounced and specific. The definition itself of physical health is narrower and more precise than that of mental health. Therefore, if there are publications reporting the harmful impact of natural environment pollutions on human organism, they are mostly focused on physical aspects. Mental health is conditional on many aspects and one cannot determine with absolute certainty which factor prevails in a given specimen. And an attempt at extending this conclusion to the entire population is even more risky.

One can only assume that there is a relationship between environmental pollution and the mental health of the population. Neither was it possible to unequivocally prove the connection between the atmospheric air quality and the rate of social pathologies, although there are indications that suggest it exists.

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Conflict of interest statement

The authors declare no conflict of interest.

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