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# Could the lake ecosystems influence the pathogenicity of the SARS-COV-2 in the air?

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**During the first 200 days of the Covid-19 pandemic in Poland, lower morbidity and mortality due to SARS-COV-2 infection were recorded in three regions covered by many small and large lakes (West Pomerania 5.8 deaths/100 000 population, Warmian & Masurian 7.6 deaths/100 000 population, Lubusz 7.3 deaths /100 000 population, compared to Poland average of 16.0 deaths/100 000 population). Moreover, in Mecklenburg (Germany), bordering West Pomerania, only 23 deaths (1.4 deaths/100 000 population) were reported during the same period (Germany 10 649 deaths, 12.6 deaths/100 000 population). This unexpected and intriguing observation would not have been noticed if SARS-CoV-2 vaccinations were available at that time. The hypothesis presented here assumes the biosynthesis of biologically active substances by phytoplankton, zooplankton or fungi and transfer of these lectin-like substances to the atmosphere, where they could cause agglutination and/or inactivation of pathogens through supramolecular interactions with viral oligosaccharides. According to the presented reasoning, the low mortality rate due to SARS-CoV-2 infection in Southeast Asian countries (Vietnam, Bangladesh, Thailand) could be explained by the influence of monsoons and flooded rice fields on microbiological processes in the environment. Considering the universality of the hypothesis, it is important whether the pathogenic nano- or micro particles are decorated by oligosaccharides (as in case of the African swine fever virus, ASFV). On the other hand, the interaction of influenza hemagglutinins with sialic acid derivatives biosynthesized in the environment during the warm season may be linked to seasonal fluctuations in the number of infections. The presented hypothesis may be an incentive to study unknown active substances in the environment by interdisciplinary teams of chemists, physicians, biologists, and climatologists.**

**Keywords**: COVID-19, SARS-CoV-2, phytoplankton, atmosphere, lectin, lake

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**Abbreviations**: LU, Lubusz region, W&M, Warmian and Masurian region, WP, West Pomerania region, PL, Poland, *Infections per 100 000 inhabitants, **deaths per 100 000 inhabitants.

## INTRODUCTION

The global COVID-19 pandemic has led to an unprecedented mobilization of the scientific community. This defence is taking place on multiple fronts, similar to military operations, and the ongoing battle constantly brings new strategies into play. Pioneering research on transfection of conglomerates of mRNA and cationic lipids initiated by Robert Malone in 1987 (Malone *et al*., 1989) and the intuition, perseverance, and efforts of Katalin Karikó (Karikó *et al*., 2008), Uğur Şahin and Collaborators ushered perspectives for RNA vaccines (Niknam *et al*., 2022; Dolgin, 2021; Yin *et al*., 2022). In 2020 Food and Drug Administration office (USA) issued an emergency use authorization for RNA vaccines to the Pfizer–BioNTech and Moderna companies.

Independently, the effectiveness of many substances, ranging from low-molecular compounds to proteins, including antibodies and plasma of convalescent plasma therapy, has been tested. The first large-scale use of the convalescent plasma therapy was to stop the rinderpest epidemic in Poland in 1921 (Orzechowska *et al*., 2018). For therapeutic use in humans, plasma is sterilized with oxidants that modify methionine and tryptophan residues. This may result in the weakening of the effector activities of antibodies, including their interaction with the Fc receptor and complement activation (Mo *et al*., 2016). Therefore, it may be necessary to move away from routine sterilization technologies and reassess the effectiveness of improved plasma preparations (Li *et al*., 2020; Pan *et al*., 2022). Figure 1 illustrates the participation of the environment (bodies of water, atmosphere, pollens) that may modulate the activity of SARS-CoV-2 virus (Kisajno Lake, Warmia & Masurian Region, Poland) © Worldisbeautiful.eu)


**Figure 1. Illustration of the main assumptions of the hypothesis: Lake Kisajno (W&M) represents the place of biosynthesis of active substances.**
Plant pollens indicate the role of various substances that affect the activity of the SARS-CoV-2 (Picture: Kisajno Lake, Warmian & Masurian Region, Poland). © Worldisbeautiful.eu

## MATERIALS, OBSERVATIONS, AND DISCUSSION

The hypothesis of influence of aquatic plankton and fungi on airborne pathogen agglutination/inactivation (referred to hereafter as "the hypothesis") is based on official reports, perceptiveness, and reflection. Although some conclusions may seem controversial, in the Author's view, they should inspire further investigations. Analyses of the course of the pandemic were prepared by Michał Rogalski (Report based on data from the Ministry of Health, Rogalski, 2022). During the initial stages of the pandemic, significantly fewer infections and deaths were recorded in three regions of Poland (LU, W&M, WP) as compared to the rest of Poland.

Figure 2 illustrates the epidemiological situation in Poland during the first 200 days of the COVID-19 pandemic. The curves are a collection of 2281 independent points, each of which represents one human tragedy. The chart is therefore a tribute to those who died during the global COVID-19 pandemic around the world.

Two events may be important for the hypothesis construction:

- 1. Despite the enormous effort of science the introduction of vaccination was not immediate and did not obscure the observation of the first period of pandemic progression,
- 2. The winter of 2019/20, preceding the pandemic in Poland, was mild and the lakes in question did not freeze. The liquid water, in which the microorganisms lived, was constantly in contact with the air, and the transport of biomass could happen all the time. Therefore, the alleged "antiviral substances of lake origin" could protect the inhabitants of the land of the lakes.

Statistical significance of the difference between mortality curves for lake districts and the rest of Poland was calculated in GraphPad Prism using Akaike's (Bozdogan, 2000) Information Criterion. Differentiation between the curves for each data set is >99.99%. (Poland lake districts – blue line: Y=0.0072×–0.1999. $R^2$=0.943, the rest of Poland – red line: Y=0.0355×–0.3074. $R^2$=0.9772) indicating a limited progression of the disease in areas covered with lakes (LU+W&M+WP) compared to the rest of Poland. However, after 200 days of the pandemic, significant perturbations appeared. After this period, both insolation and temperature decreased, which affected the biological life in the lakes (Edwards *et al.*, 2016).

The further course of the pandemic is shown in the Fig. 3A and 3B and Table 1. Figures 3A and 3B show the ratio of the officially recorded data of SARS-CoV-2 infections or deaths in Poland to the numbers of infections in lake-covered regions for the first year of the pandemic. The ratio of (LU+W&M+WP)/PL shows differences in the dynamics of the pandemic in lake districts compared to the rest of Poland. The intersection of the blue and red curves coincides with the onset of temperatures at which the lakes reach their freezing point. The data may suggest the possibility of a protective role of lakes during the COVID-19 pandemic. Paradoxically, the protective role of lakes presumably delayed the induction of herd immunity, contributing to an increase in infections and deaths in the cold period while the lakes froze (winter 2020/21).

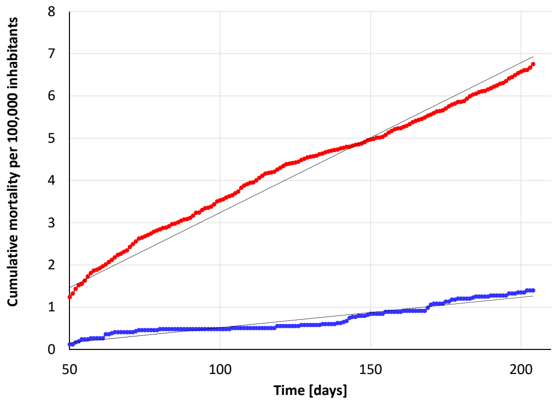


**Figure 2. Cumulative mortality per 100 000 population during the first 200 days of the COVID-19 pandemic in Poland (from March 2020 to 19 September 2020).**
Blue line: deaths per 100 000 inhabitants in "lake-rich regions": LU+W&M+WP, red line: deaths per 100 000 inhabitants in the rest of Poland (source data: Rogalski, 2022). Statistical significance (different curves for all data set >99.99%). was calculated using GraphPad Prism, Akaike's Information Criterion (Bozdogan, 2000).

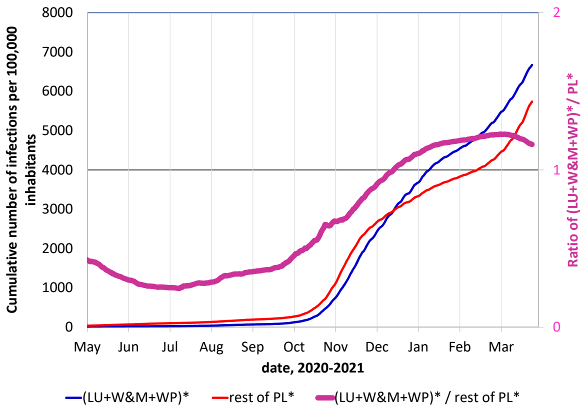


**Figure 3A. Coronavirus infections/100 000 population in (LU+W&M+WP) (blue) and in the rest of Poland [PL- (LU+ W&M+WP)] (red).**
The bold purple line shows the ratio between cases per 100 000 population in the (LU+W&M+WP) and the cases in the rest of Poland (May 2020/March 2021). It should be added that the official reports on the number of SARS-CoV-2 infections in Poland can be considered as estimates (data for May 2020–March 2021).

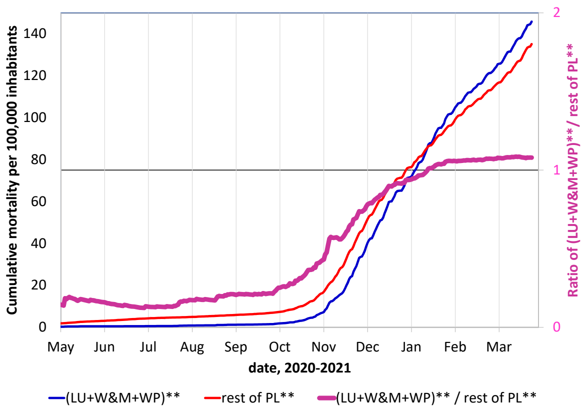


**Figure 3B. Cumulative coronavirus deaths/100 000 population in the lake-rich regions (LU+W&M+WP), (blue) and in the rest of Poland [PL- (LU+W&M+WP)] (red).**
The bold purple line depicts the ratio between mortality in the (LU+W&M+WP) regions and the rest of Poland (data for May 2020–March 2021).

**Table 1. Cumulative COVID-19 cases and deaths in Poland's lake-rich regions between May 1, 2020, and April 1, 2021.**
LU, Lubusz region; W&M, Warmian and Masurian region; WP, West Pomeranian region; PL***, Poland excluding the three lake-rich regions (LU+W&M+WP). Table presents the total number of COVID-19 cases and deaths since the beginning of the pandemic (Rogalski, 2022).

| Region | Date | Infections/100 000 population | Number of infections | Deaths/100 000 population | Number of deaths |
|---|---|---|---|---|---|
| LU | 1 May 2020 | 8.6 | 87 | 0 | 0 |
| W&M | | 10.5 | 148 | 0.07 | 1 |
| WP | | 23.7 | 401 | 0.59 | 10 |
| PL*** | | 36.3 | 12469 | 1.84 | 632 |
| LU | 1 Jun 2020 | 11.7 | 118 | 0 | 0 |
| W&M | | 12.7 | 179 | 0.07 | 1 |
| WP | | 31.7 | 536 | 1.12 | 19 |
| PL*** | | 62.9 | 24159 | 3.04 | 1054 |
| LU | 1 Jul 2020 | 15.0 | 151 | 0 | 0 |
| W&M | | 17.8 | 250 | 0.07 | 1 |
| WP | | 36.1 | 611 | 1.30 | 22 |
| PL*** | | 94.1 | 32293 | 4.28 | 1470 |
| LU | 1 Aug 2020 | 40.6 | 410 | 0.99 | 10 |
| W&M | | 26.7 | 379 | 0.14 | 2 |
| WP | | 43.8 | 741 | 1.36 | 23 |
| PL*** | | 135.1 | 46348 | 4.92 | 1686 |
| LU | 1 Sep 2020 | 69.9 | 706 | 1.39 | 14 |
| W&M | | 63.5 | 902 | 0.64 | 9 |
| WP | | 67.8 | 1132 | 1.59 | 27 |
| PL*** | | 190.2 | 65252 | 5.85 | 2008 |
| LU | 1 Oct 2020 | 105 | 1046 | 1.88 | 19 |
| W&M | | 124 | 1745 | 1.20 | 17 |
| WP | | 110 | 1869 | 2.15 | 36 |
| PL*** | | 258.9 | 88821 | 7.20 | 2470 |
| LU | 1 Nov 2020 | 724 | 7310 | 7.20 | 72 |
| W&M | | 654 | 9292 | 7.55 | 106 |
| WP | | 679 | 11478 | 5.79 | 98 |
| PL*** | | 1025 | 351813 | 16.0 | 5507 |
| LU | 1 Dec 2020 | 2188 | 22097 | 36.8 | 372 |
| W&M | | 2330 | 32702 | 40.2 | 565 |
| WP | | 2269 | 38460 | 35.0 | 497 |
| PL*** | | 2574 | 882979 | 47.1 | 16154 |
| LU | 1 Jan 2021 | 3114 | 31457 | 67.7 | 684 |
| W&M | | 3805 | 54032 | 84.1 | 1195 |
| WP | | 3758 | 62762 | 62.3 | 1041 |
| PL*** | | 3293 | 1129575 | 75.9 | 26031 |
| LU | 1 Feb 2021 | 3690 | 37273 | 95.0 | 960 |
| W&M | | 4738 | 67289 | 119.5 | 1679 |
| WP | | 4732 | 75903 | 90.7 | 1536 |
| PL*** | | 3787 | 1299088 | 96.3 | 33034 |
| LU | 1 March 2021 | 5478 | 43945 | 116.4 | 1176 |
| W&M | | 5985 | 82089 | 140 | 1988 |
| WP | | 5314 | 87416 | 114 | 1901 |
| PL*** | | 4260 | 1461250 | 115 | 39521 |

| | | | | | |
|---|---|---|---|---|---|
| LU | 1 April 2021 | 6137 | 61983 | 146 | 1472 |
| W&M | | 7678 | 109032 | 172 | 2442 |
| WP | | 6480 | 108216 | 130 | 2172 |
| PL*** | | 5917 | 2029658 | 138 | 47503 |

### The impact of the inland water ecosystems and climate in neighbouring and distant countries on the COVID-19 pandemic

To further evaluate this hypothesis, the epidemiology of COVID-19, as of October 2020, was analysed in countries neighbouring Poland and having similar climate and inland water reservoirs. The observed mortality per 100 000 population in the five chosen regions was as follows: Lithuania, 4.0**, Latvia, 2.5**, Estonia, 5.3**, Finland, 6.2** (Worldometer COVID-19, 2023), Kaliningrad Oblast, 9.7**, while in the reference regions it reached 21.6** in Europe and 17,5** in Russia (Development of Number of Coronavirus, Russia, 2022). Due to the impact of soil and lakes acidification, Sweden was excluded from the present considerations (Almer & Dickson, 2021). As shown in Fig. 4 during the first period of the pandemic, each of the five analysed regions reported low mortality rates from COVID-19. For example, in Mecklenburg-Vorpommern, a German land bordering Western Pomerania and rich in lakes, only 23 (1.43**) deaths were recorded until November 1, 2020, while, at the same time, the mortality rate for the entire Germany amounted to 10 649 (12.8**) deaths. Also

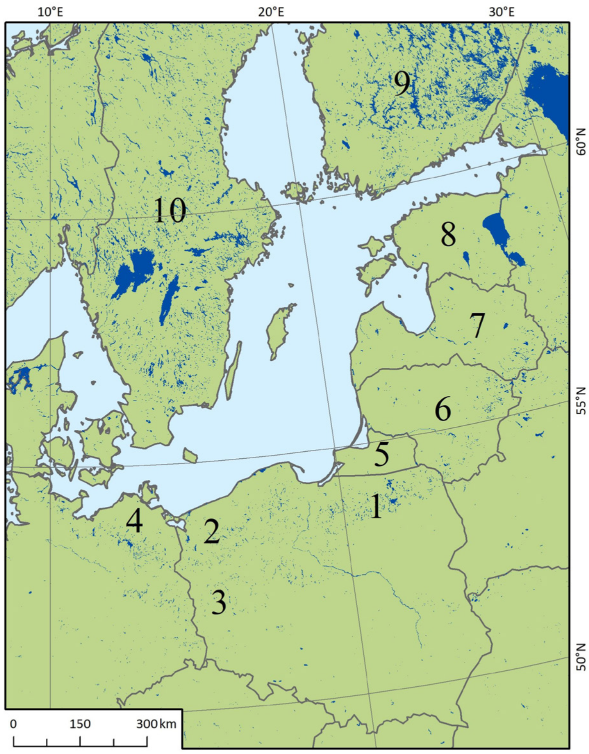


**Figure 4. Map of the selected fragment of Central Europe: (1) W&M – Warmian & Masurian (Poland), (2) WP – West Pomerania (Poland), (3) LU – Lubusz (Poland), (4) Mecklenburg (Germany), (5) Kaliningradskaja Obłast (Russia), (6) Lithuania, (7) Latvia, (8) Estonia, (9) Finland, (10) Sweden.**
The map was made using ArcGIS 10.7.1 software and the geographical data were taken from WWF and Eurostat databases (https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database, https://ec.europa.eu/eurostat/web/gisco/geodata).

later, the pandemic situation in Mecklenburg (62.5**) remained more favourable than in the rest of Germany where it amounted to 101.6** (83292) deaths (2 May 2021). (Development of number of Coronavirus cases: Mecklenburg-Vorpommern, Germany, 2022)

In addition, the progression of the pandemic was analysed in three Asian countries: India, Bangladesh (Beaney *et al.*, 2021), and Iran. These countries differ in climate and population density, which amounts to 460, 1260 and 52 inhabitants/km$^2$, respectively The official COVID mortality data for the period from the beginning of the pandemic to November 14, 2022 are as follows: India 37.7**, Bangladesh 17.5**, and Iran 168.2** (Worldometer COVID-19 Coronavirus Pandemic, 2023). These numbers, opposite to expected in terms of the relationship between population density and mortality due to COVID-19, prompt discussion. Two of the distinguishing features of these countries, apart from population density, are climate and rainfall. Bangladesh has tropical-monsoon warm climate, India is a hot tropical country, and Iran is mainly arid and semiarid. In the context of the presented hypothesis, the spread and growth of phytoplankton, zooplankton and fungi in rice-growing areas cannot be overlooked (Nam *et al.*, 2022, Anyanwu *et al.*, 2001). For example, in Bangladesh, rice fields cover over 7% of the country's land area. Other global rice producers also show low mortality due to COVID-19 (for example: Thailand – 47.4**, Vietnam – 43.6** (December 2022).

Moreover, in the light of this hypothesis, the microbiological status of the warm seas of Southeast Asia should also be considered (Cochran *et al.*, 2017; Gao *et al.*, 2021).

Therefore, it would be interesting to study and compare the antiviral properties of substances produced and released into the atmosphere by phytoplankton, zooplankton, and fungi in various climatic zones in Central Europe, Southeast Asia, Canada, etc.

### Transfer of lake biomass into the atmosphere.

The aquatic environment is in constant equilibrium with the atmosphere. I assume that phytoplankton, under the influence of wind and waves, is blown off the surface of lakes or thrown out onto the coastline of small and large lakes to undergo biodegradation, biotransformation, drying, etc., and is disseminated by wind in the local atmosphere. In the case of the Great Lakes in the USA, biological matter from the lakes was found about 25 km from the coastline (May *et al.*, 2018). Moreover, gas bubbles from the depths of the lakes transfer biological matter to the surface of water. These bubbles burst upon reaching the air/water boundary, transferring biomass into the atmosphere (Blanchard & Syzdek, 1970, Cochran *et al.*, 2017, Kim *et al.*, 2020). This can be compared to the behaviour of bubbles on the surface of carbonated beverages. A pioneering study on the transfer of biological matter (*B. fluorescens liquefaciens* and *B. fluorescens putidus*) from water reservoirs to the atmosphere was conducted in 1887 by Odo Bujwid (Bujwid, 1887).

The interaction of gas bubbles with the matter present in aqueous environment is a multifaceted process widely used in flotation technology (Krasowska, *et al.*, 2019). The surroundings of the lakes are sometimes accompanied by a subtle odor, which can result from biological life in the lakes. Phytoplankton content in Polish lakes fluctuates qualitatively and quantitatively from year to year and month to month (Napiórkowska-Krzebietke & Hutorowicz, 2006).

Cyanobacteria (blue–green algae), a constituent of phytoplankton, produce chemically diverse antiviral compounds such as lectins, cyclic peptides, lipopeptides, fatty acids, alkaloids, and saccharides (Codd *et al.*, 2016, Mazur-Marzec *et al.*, 2021, Sami *et al.*, 2020, Singh *et al.*, 2017). Aggregates of blue-green algae in water often display compact, strong, spongy structures resulting from specific and nonspecific interactions with a variety of macro- and nanomolecules.

For a long time, it was believed that lectins play a role in the plant world only. The overthrow of this dogma in 1975 opened new perspectives in science, medicine, and technology. The antiviral activity of lectins against SARS-CoV-2 has been investigated, but all studies have been conducted in an aquatic environment (Wang *et al.*, 2021, Gupta & Gupta, 2022, Nabi-Afjadi *et al.*, 2022, Stravalaci *et al.*, 2022, Simplicien *et al.*, 2022).The virus, being molecularly dispersed in air (Greenhalgh *et al.*, 2021, Nissen *et al.*, 2020), could interact with water (moisture) and/or with organic and inorganic pollutants (Yang & Marr, 2020, Domingo & Rovira, 2020, Ishmatov, 2022, Damialis *et al.*, 2021, Rzymski *et al.*, 2022).

From the perspective of the presented consideration, the key point would be to investigate the interaction between viral oligosaccharides (Zhang *et al.*, 2021, Banerjee & Mukhopadhyay, 2016) and macro- and nanoparticles of lake origin in the air. A resulting hybrid nanoparticle, similar in architecture to a conjugate vaccine, could not only interact with the virus itself but could also activate the immune system.

The aim of this hypothesis is to explain the reasons for the lower COVID-19 infection and death rates in the lake-rich regions. Three regions of Poland (LU, W&M, WP) have a large number of lakes (covering 4.4% of the total region area) and low population density (70/km$^2$ *versus* 120/km$^2$ for the entire Poland). In Poland, the average population density relies on the number of cities rather than the uniform dispersion of the population. Moreover, the official population density reports do not include mass tourism to these lake areas. Despite many analyses, the search for consensus linking population density with pandemic progression is still ongoing (Moosa & Khatatbeh, 2021).

## CONCLUSIONS

The hypothesis presented herein raises the following questions:

- How would the transfer of biological matter from the lakes to the atmosphere take place?
- How can the substances from phytoplankton potentially neutralize the SARS-CoV-2 virus?
- What is the epidemiological situation in Poland and its neighbouring lake-rich countries?
- What could be the practical consequences of the existence of antiviral bio-aerosols?

It should be added that the official reports on the number of SARS-CoV-2 infections in Poland can be considered as estimates. The observed fluctuations in the number of infections may be due to the seasonal presence of biological substances released into the environment. For example, it was shown that the presence of pollen in the air correlates with increased COVID-19 morbidity (Damialis *et al.*, 2021).

The type of chemical supramolecular bonds between a virus and a carrier (hydrogen bonds, van der Waals forces, ion-ion, and π-cation interactions) may be crucial for its biological activity. Hypothetically, interactions of pathogens with airborne contaminants could contribute to viral infectivity in two different ways. If, as a result of the interaction, the virulence factors are not blocked, the pathogen's activity may increase (Damialis *et al.*, 2021) in a mechanism of avidity. Conversely, if the molecules critical for viral infectivity are blocked, pathogenicity may be reduced.

The moderate sensitivity and selectivity of the interactions between lectins and sugars (Sharon & Lis, 2001) enables for the potential application of this mechanism to a broad range of viruses. If the mutations do not significantly alter the glycosylation of viral envelope, these "airborne lectins" could neutralize also the new strains (Markov *et al.*, 2022, Barre *et al.*, 2022). Interactions of pathogen's sugars with lectins in aerosols could contribute to local inactivation of the dispersed viruses. As an example, assuming this line of thinking is correct, the inactivation of the ASF virus could be a result of an interaction of its glycolipids (Del Val & Vinuela, 1986) or saccharides (Zhu, 2022) with molecularly dispersed lectins from selected legume seeds.

From a practical point of view, spraying of the nanocomponents present in phytoplankton in the air in populated areas (city centres, transportation vehicles, etc.) could entrap viral particles *via* lectin-virus interactions and lower the transmission rate at low cost and low risk. Hybrid nanoparticles (lectin-agglutinated viruses) suspended in the still air would sediment faster than virus particles alone, according to Stokes's law (though air turbulences would interfere with the sedimentation process) (Adamczyk, 2006). Agglutination and/or aggregation of viruses may affect their biological activity and modify their physicochemical properties (Gerba & Betancourt, 2017, Del Val & Vinuela, 1986, Szermer-Olearnik *et al.*, 2017).

The interpretation of the reasoning presented in the hypothesis goes beyond the environment of water bodies and includes the air temperatures.

This is prompted by the report on the course of the COVID-19 pandemic in 2020–2023 (Fig. 5).

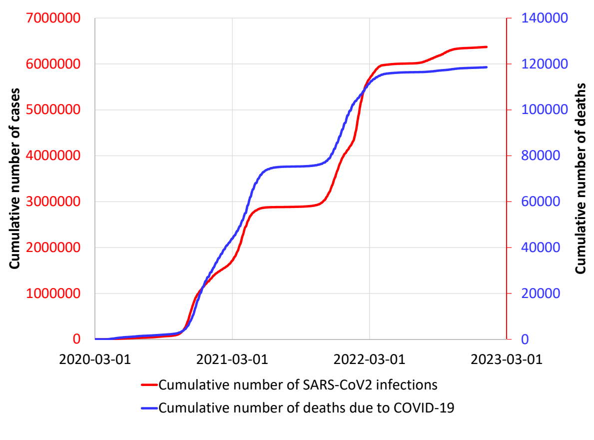


**Figure 5. Infectivity and mortality during the COVID-19 pandemic in Poland (2020–2023). Based on Worldometer COVID-19 Coronavirus Pandemic (2023).**

**Table 2. Infectivity and mortality during the COVID-19 pandemic in Poland in arbitrarily designated cold and warm periods of the year.**

| Period of year | Date | Average number of infections/day | Average number of deaths/day |
|---|---|---|---|
| Warm | 01/05–01/10 2020 | 534 | 12.3 |
| Cold | 01/11–01/03 2020/21 | 10 800 | 316.6 |
| Warm | 01/05–01/10 2021 | 724 | 64.6 |
| Cold | 01/11–01/03 2021/22 | 21550 | 290 |
| Warm | 01/05–01/10 2022 | 1 750 | 10.3 |
| Cold | 01/11-01/03 2022/23 | 676 | 6.4 |

Data source: Worldometer COVID-19 Coronavirus Pandemic (2023).

Comparing the infection rates in warm and cold seasons, it can be observed that low disease propagation was found in the warm periods and conversely, high incidence occurred in cold periods. The seasons of the year are arbitrarily determined (cold period: 1st Nov/1st March, warm period: 1st May/1st Oct). The reduced mortality observed at the end of 2022 may be due to the changes in the profile of viruses circulating in the environment.

Table 2 presents the influence of the seasons on the progression of the COVID-19 pandemic in Poland. According to the main idea of the hypothesis, this phenomenon could be explained by the release into the atmosphere of biologically active substances related to vegetation, agriculture, and putrefactive processes of decay, especially during warm periods (Góralska *et al*., 2022).

A similar correlation applies to the widely studied influenza. Viral hemagglutinins which are an integral part of viruses play a key role in the pathogenesis of infection through interactions with sialic acid terminated glycans.

One may ask why the number of flu cases decreases in the warm season. According to the hypothesis, one of the reasons that can be considered is the release of sialic acid derivatives into the atmosphere. Numerous bacteria species biosynthesize sialic acid polymers (González-Clemente *et al*., 1989) and fungi produce a variety of the derivatives of sialic acid (Alviano *et al*., 1999). These substances released into the atmosphere could agglutinate and/or neutralize influenza viruses.

Addressing these complex problems highlighted by the hypothesis presented here, would require interdisciplinary efforts in medicine, biology, chemistry, climatology, and biophysics. The first step could be the attempt at isolation of the alleged active substances from the atmosphere using electroseparators dedicated for biological components (Maineli *et al*., 2002). Another approach could be used to pass air through the filters containing immobilized oligosaccharides to specifically adsorb the sought-after biomolecules. The task of isolating the active substance from the air could prove similar in scale to the challenge of obtaining 8 mg erythropoietin from 2550 litres of urine (Miyake *et al*., 1987) (the value of the erythropoietin market in 2021 was USD 8.8 billion). The observation would not have been made if it had not been for two facts. Until January 2021, the progression of the pandemic was not hindered by vaccination programs as the introduction of vaccines followed the observed phenomena. Moreover, the winter of 2019/2020 was exceptionally warm and Polish lakes did not freeze for the first time in many years, enabling the "biology and biochemistry in water" to interact with the air constantly.

**Appendix (Dec. 2022).**

COVID-19 deaths/100 000 inhabitants: Poland 314** (LU 332**, WP 278**, W&M 326**), Finland 140**, Latvia 331**, Lithuania 355**, Estonia 213**, Germany 190**, Mecklenburg 162.5**, Canada 126** (more than 9% of Canada is covered by lakes), USA 332**, all countries 85.6** (Worldometer COVID-19 Coronavirus Pandemic, 2023).

## Declarations

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