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# An environmental and health perspective for COVID-19 outbreak: Meteorology and air quality influence, sewage epidemiology indicator, hospitals disinfection, drug therapies and recommendations

Damia Barcelo[a,b,c,*]

[a] Water and Soil Quality Research Group, Department of Environmental Chemistry, IDAEA-CSIC, C/Jordi Girona 18–26, 08034 Barcelona, Spain
[b] Catalan Institute for Water Research (ICRA), C/Emili Grahit 101, 17003 Girona, Spain
[c] College of Environmental and Resources Sciences, Zhejiang A&F University, Hangzhou 311300, China

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ABSTRACT

This Opinion Paper wishes to provide a summary of recent findings and solutions for a better understanding of the environmental and health problems associated with COVID-19. The list of topics covered is large: meteorology and air quality factors with correlation number of infections, sewage waters as a way to reveal the scale of COVID-19 outbreak, current hospital disinfection procedures and new eco-friendly technologies and list of drug therapies recommend waiting for the desired vaccine to come. During the last two months we did notice an increase in the scientific literature regarding COVID-19 with a partial vision of this problem. The current Opinion Paper is one of the first attempts, to my understanding, to summarize and integrate environmental and human health aspects related to the monitoring, fate and treatment solutions for COVID-19. That being said I believe that this Opinion Paper can serve as multipurpose document, not only for scientists of different disciplines but for social media and citizens in general.

## 1. Introduction

In December, 2019, a series of human pneumonia cases of unknown cause emerged in Wuhan, Hubei, China. Sequencing analysis from lower respiratory tract samples indicated a novel coronavirus, which was named 2019 novel coronavirus (SARS-Cov-2) that caused clusters of fatal pneumonia with clinical presentation greatly resembling SARS-CoV [1–3]. COVID-19 started in China but now is present in many different countries with the highest number of cases in US, Italy and Spain among others. To better understand this new global epidemic from the environmental and health perspective I have decided to select the very recent papers published in the scientific literature and to prepare this Opinion Paper for JECE. Air compartment plays a key role in COVID-19 transmissions specially meteorological factors such as weather conditions, temperature, humidity and air pollution PM10, Black Carbon and NOx. But the presence and evolution of COVID-19 virus in other environmental compartment such as water, soils, wastewater and sewage sludge needs attention as well [4]. Sewage can be used to determine the scale of COVID-19, the so-called Sewage Epidemiology or Waste Based Epidemiology (WBE) approach. In untreated waste water the virus causing COVID-19 (via feces introduced in waste water) can survive from hours to days. First data on COVID-19 in sewage in Europe was reported recently in the Netherlands, by RIVM National Institute for Public Health and the Environment. Patients with COVID-19 in their gastrointestinal tract will thus excrete it in their feces. RIVM has previously used this approach to detect the presence of norovirus, antibiotic-resistant bacteria, the poliovirus and the measles virus in wastewater [5].Few weeks later COVID-19 virus was detected in sewage waters from Australia [6] and Paris, France [7]. Detection of SARS-CoV-2 is generally carried out with nucleic acid–based polymerase chain reaction(PCR) assay, used for confirmation of COVID-19 patients around the globe. PCR has high sensitivity and specificity, requirements for complicated sample handling in the laboratory, skilled personnel, and a long period of data processing and analysis (4–6 h).

Hospitals need as well our attention. Do we know if our current disinfection technologies are enough to treat the virus? Medical doctors, hospital personnel and the patients are staying in as safe facility? Examples on general disinfection procedures and new treatment technologies will be reported too. To that end a drug therapy options for humans is needed for COVID-19 infection before a vaccine is ready. Few

* Corresponding author at: Water and Soil Quality Research Group, Department of Environmental Chemistry, IDAEA-CSIC, C/Jordi Girona 18–26, 08034 Barcelona, Spain.
*E-mail address:* dbcqam@cid.csic.es.

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examples based on different drug therapies were reported and are being used in trials in the US, France and Spain.

## 2. Meteorology and air quality influence

Zhou and Xie [8] report a comprehensive study on COVID-19 infection in 122 Chinese cities during January-February 2020. The most relevant finding is that there is no evidence supporting that case counts of COVID-19 decline with warmer weather. This is one of the few studies that does not find a decrease on COVID-19 outbreak when ambient temperature increases. Most of all other studies reported indicate just the contrary, warmer temperature should decrease COVID-19 outbreak. One reason could be that this study was performed in winter time, with lower temperatures than spring or summer period. In contrast Luo Bin et al. [9] describe the effects of daily temperature and humidity on daily deaths of COVID-19 that took place in Wuhan during January-February this year that is the same period as with Zhou and Xie [8]. In this case the findings indicate that increase of temperature and humidity had a positive effect and the number of COVID-19 deaths which decreased. Same effect was also noticed in Jakarta, Indonesia, from January-March 2020 [10]. But in addition to the meteorological factor the very high mobility and high density of the people living in Jakarta, with around 9. 6 millions inhabitants, is a key factor for fast transmission of COVID-19.

Air quality seems to be as well a key environmental factor on the COVID-19 infections. Two recent studies were performed in this regard in the North of Italy this year [11,12]. Results reported in both studies go in the same direction. There is a high association of COVID-19 infections with air pollution of cities measured during days exceeding the limits set for PM10 or ozone in previous years [11]. A relevant conclusion of this work [11], and others also published, is that at cities with poor air quality like some in the North of Italy increased probability of COVID-19 infections are mainly due to air pollution-to-human rather than to human-to-human.

The other selected paper also from North of Italy indicates that Lombardy and Emilia Romagna are some of the European regions with the poorest Air Quality Index, defined as PM10, PM 2.5, $O_3$, SOs and $NO_2$ [12]. Defenses of specially elderly living in this region could have been weakened both by age and chronic exposure to air pollution. Prolonged exposure to atmospheric pollution could induce persistent modifications of the immune system and this will boost COVID-19 infections and eventually to death, particularly in case of severe respiratory and cardiovascular problems.

The improvement of air quality in Barcelona, Spain, under lockdown measures was recently reported [13]. After two weeks of lockdown, urban air pollution markedly decreased but with substantial differences among pollutants. The most significant reduction was estimated for Black Carbon and $NO_2$ (-45 to -51 %), pollutants mainly related to traffic emissions. A lower reduction was observed for PM10 (-28 to -31.0 %). By contrast, $O_3$ levels increased ( + 33 to + 57 % of the 8 h daily maxima), probably due to lower titration of $O_3$ by NO and the decrease of NOx in a VOC-limited environment. In the same direction correlation between $NO_2$ levels with COVID-19 outbreak analysis has been conducted on a regional scale and combined with the number of death cases taken from 66 administrative regions in Italy, Spain, France and Germany [14]. Results show that out of the 4443 fatality cases, 3487 (78 %) were in five regions located in North Italy and central Spain. Additionally, the same five regions show the

highest $NO_2$ concentrations combined with downwards airflow which prevent

an efficient dispersion of air pollution. Recently this work [14] did receive negative comments since $NO_2$ were only collected by satellite and no ground measurements were included. Such correlation may not be applicable to other countries such as Taiwan that although exhibits high $NO_2$ levels does not follow the same pattern with low COVID-19 infections.

Another factor that may influence COVID-19 infections is the pollen, that starts in spring. A recent paper from the Netherlands is not on COVID-19 but flu and collects data from the last four years [15]. Summarizing the results indicates that more pollen in the air might make more difficult for flu-like virus to survive outside the host, acting the pollen as firewall. Pollen in the atmosphere increases general immune-responses and are a casual factor reducing the spread of flu-like viruses. To that end, the authors indicate that there is a possibility that COVID-19 will be seasonal “going away” in May.

## 3. Sewage epidemiology indicator

Christian Daugthon [16], former EPA scientist and pioneer on the WBE concept reported about the urgency among researchers for the need to develop Waste Based Epidemiology methods not just for COVID-19, but also for future epidemics. Basic principle is that sewage can be used as indicator of the scale of infection and it will boost worldwide attention and interest in WBE. Daughton and many others we do believe that collective efforts of the WBE community need to be granted as recognition that they deserve in addressing ongoing, urgent needs of public health. The first data detecting COVID-19 in sewage from the Netherlands [5], Australia [6] and Paris, France [7] supports this idea of using WBE to reveal the scale of COVID-19 outbreak. Several other papers [16–21] reported the importance to detect viruses in untreated wastewater samples and to develop paper sensor devices to measure directly in wastewaters.. These measurements were carried out using PCR, the most widely used method for COVID-19 detection. Paper-based devices are powerful and cheap tools for the rapid diagnosis of pathogens and determination infection of transmission [17]. It contains different functional areas printed with a wax printer into a cheap paper material. The whole testing process using this paper-based device is very fast and sensitive, which overcomes the limitation of PCR and it was used for a variety of infections such as malaria and several pathogens [17].

Other papers published in the literature already reported the presence, and fate of enveloped viruses [18] or the inactivation of an Enveloped Surrogate Virus in Human Sewage [19]. The results of this last paper were performed as a way to model Ebola presence in sewage. The inactivation kinetics of enveloped viruses in sewage used certain bacteriophage, as RNA member of the *Cystoviridae*, as a potential surrogate for enveloped human viruses in sewage. Results reported that it can undergo 6–7 log inactivation in sewage in 3–7 days, depending on temperature.

Another relevant paper reported how much reduction of virus is needed for recycled waste water recommending an additional 2- to 3-log reduction of viruses above current recommendations to ensure safe recycled water [20]. The last paper selected concerning the presence of viruses in wastewaters is also about the survival of two surrogate coronaviruses, transmissible gastroenteritis (TGEV) and mouse hepatitis in water [21]. The authors did find out that these viruses remained infectious in water and sewage for days to weeks. At 25 _C, time required for 99 % reduction in reagent-grade water was 22 days for TGEV. At present we do not know if the same is applicable to COVID-19 and for how long it can remain in water. What we know from recent studies is that fecal transmission routes should be considered, as the COVID-19 virus has been positively detected in stool samples of infected patients. Studies have shown that SARS-CoV can survival in stool samples for 4 days [22] or even up 22 days, much longer than in respiratory (18 days) and serum samples (16 days) collected from patients of Zheijiang province hospital [23]. In short, infected stools in wastewater can generate further transmission routes through aerosols formation during wastewater treatment.

## 4. Hospitals disinfection

Hospitals are key element to treat and recover patients infected with COVID-19. Disinfection techniques most appropriate for the rooms, personnel and medical equipment are required. An interesting study performed on indoor air quality at the largest hospital in Iran [24]. The air of patient rooms with confirmed COVID-19 was investigated last March 2020. Viral RNA was extracted and analyzed by PCR (RT-PCR). Fortunately, in this study all air samples which were collected 2–5 m from the patients' beds with confirmed COVID-19 were negative. The indoor air was not contaminated with the virus causing COVID-19. The authors suggested as well to perform *in vivo* experiments using actual patient cough, sneeze and breath aerosols in order to show the possibility of generation of the airborne size carrier aerosols and the viability fraction of the embedded virus in those carrier aerosols. Disinfection technologies at hospitals are certainly a key issue to avoid the large number of medical doctors and front-line healthcare workers (HCW) that is being continuously infected by COVID-19. Neil Rowan [25] presents a comprehensive insight into this pressing need with preference towards environmental-friendly sustainable disinfection technologies. This is needed too because of the shortage in supply chain of critical one-time-use personal and protective equipment (PPE). PPE are heat sensitive and are not, by their manufacturer's design, intended for reprocessing. Most conventional sterilization technologies used in hospitals, or in terminal medical device sterilization providers, cannot effectively reprocess PPE due to the nature and severity of sterilization modalities. Eco-friendly technologies are being recommend and used in Ireland, namely vaporized hydrogen peroxide (VHP), such as for filtering face piece respirators and UV irradiation. To be added that UV irradiation was already recommend for other disinfection applications including toilet flushing [26]. Ultraviolet waveband C (UV−C) for disinfection was effective for the three types of bacteria studied: *Staphylococcus epidermidis, Escherichia coli, and Salmonella typhimurium*. An excellent review and recommended reading on photocatalytic disinfection technologies for waterborne viruses was recently published last year [27].

Disinfection procedures applied to hospitals indoor facilities developed in China used mainly chlorine [28]. For the contaminated areas, disinfection four times daily, the environment, air, floor and the surface of tables are sprayed with a 2000 mg/L chlorine-containing disinfectant for no less than 30 min. Less contaminated areas will require less chlorine and daily frequency. For the air disinfection window opening, UV irradiation for 30 min and spraying with 500 mg/L chlorine-containing disinfectant for more than 30 min are common methods. These disinfection procedures are being sued in Europe too.

## 5. Drug therapies

Recently published papers on treatment options and a list of drugs available have been reported recently in the literature to help with COVID-19 like antiviral drugs, anti-malaria and anti-inflammatory [3,29–31]. There are also publications, mainly from China and India [3], who recommended traditional medicinal plants to treat COVID-19. Several agents are being used under clinical trial and compassionate use protocols based on *in vitro* activity (against COVID-19 or related viruses) and on limited clinical experience. Efficacy has not been established for any drug therapy. This list includes antimicrobials with potential activity against COVID-19: Chloroquine and Hydroxychloroquine both used – *In vitro* and limited clinical data suggest potential benefit [29]. Other therapeutic drugs are Lopinavir; Remdesivir [31] and Favipiravir – their potential use is being studied. Azithromycin and Immunomodulating agents are used in some protocols based on theoretical mechanisms and limited preliminary data as adjunct therapy, COVID-19 convalescent plasma is also under investigation, NSAIDS –such as paracetamol and bronchodilators are as well in this list.

Out the list of therapeutic drugs reported the antibiotic azithromicyn added to the anti-malaria drug hydroxychloroquine is used in clinical trials in Marseille, France and some parts of US. Important information needs to be added to the use of these therapies. During the submission of the revised version of this Opinion Paper the US National Institute of Allergy and Infectious Disease (NIAID) did question the use of hydroxychloroquine as drug therapy. Also recently Ivermectin, an FDA-approved anti-parasitic previously shown to have broad spectrum anti-viral activity *in vitro*, was shown to be an inhibitor of COVID-19 [30]. Certainly Ivermectin therefore warrants further investigation for possible benefits in humans. In the meantime these pharmaceuticals are beneficials for humans waiting for the vaccine to come.

## 6. Conclusions and recommendations

It is obvious that COVID-19 was not in our radar a couple of months ago, everybody thought this was a Chinese problem but now is already a global threat. To make things easier for everybody the commonly used Environmental Source-Pathway-Receptor' (SPR) concept can be used to explain COVID-19. The source are infected humans and a risk-based approach/measure was applied: isolate the sources and/or cure the sources. The pathway it clear too: Covid-19 spreads *via* aerosols, sneezed our coughed out by infected humans. The virus thus gets direct to the receptor. Or sticks to all kinds of surfaces: plastics, stainless steel, *etc.* But stays only active for few hours-days. Finally the receptors are other humans and the risk-based approach is to isolate the receptors or make them immune by a vaccine, or move receptors away to an area with no source-pathway.

In untreated wastewater we already know that SARS-Cov-2 is present, maybe even for several weeks. Gastrointestinal symptoms caused bySARS-CoV-2 infections as well as its presence in feces of COVID-19 patients and in wastewater was already shown. Still one of the major challenges in SARSCoV-2 detection/quantification in wastewater samples is the lack of an optimized and standardized protocol. WBE can help solving the pressing problem of insufficient diagnostic testing and it will provide a cheap and early warning method for COVID-19 outbreak. To make things crystal clear WBE will be complementary and not an alternative to the compulsory PCR detection of COVID-19 in humans. Papers reported up till now on other types of viruses indicate that different viruses remained infectious in water and sewage for 3–7 days to 2–3 weeks. Special attention needs to be paid to the aerosol formation during wastewater treatment. The key question would be to know for how long COVID-19 will survive in sewage remains open.

That being said, COVID-19 will stay with us for quite some time. Now we know much more than few months ago but still we need to do more to solve this global threat. Future measures should include more comprehensive surveillance of the environment through air and water, in addition to the availability of rapid ELISA/biosensors/Paper-based tests for screening the general population and the sewage against COVID-19. Paper-based devices would be certainly one of the best measurement solutions for the rapid and on-site detection of COVID-19 in sewage waters and humans as well. I am aware that different research groups are already working on this direction being a perfect example the recent paper on the development of optomechanical spectrometry detection showed a promising solution towards the fast detection of label-free diagnosis of infectious diseases [32]. In addition to the development of new detection methods, theoretical computational analysis has been recently reported as a way to identify active coronavirus infections locally and globally using WBE. It was applied to the COVID-19 virus monitoring in Tempe, AZ, US as case study. Assumptions made for modeling did consider daily excretion rates in human stool samples between 100 − 400 g of feces/person [33].

As regards to protective measures for the employees working in wastewater treatment plants most of them are already in place, since wastewaters contain different microorganisms and it is part of their common practice. The list of measures includes: to avoid direct contact

with wastewater, to avoid ingesting, swallowing and/or breathing in wastewater spray or mist and to wear personal protective equipment. Protective measures for workers at places at high risk like hospitals and other medical care facilities is certainly more important and need to be in place. In Spain up till now 15 % of the people infected by COVID-19 virus were medical doctors and hospital personnel. Safeguarding supply chain of PPE will sustain vital healthcare provision and will help to reduce mortality. We need to plan strategically to ensure global manufacture, access, protection, and monitoring of supply chains in the face of unescapable shortages, cost increases, and national hoarding. All our fates are bound together, and any helpful products must be recognized as global assets.

In short, still a lot of work needs to be done and hopefully this Opinion Paper will help not also scientists but general public that wants to know a bit more about this new and terrific coronavirus that will keep all of us busy for quite some time in the years to come.

## Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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