



The Impact of Environmental Pollution on Public Health in Light of the COVID-19 Pandemic in Fragile and Conflict Settings: Reflections from the Gaza Strip

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PALESTINE AND JORDAN



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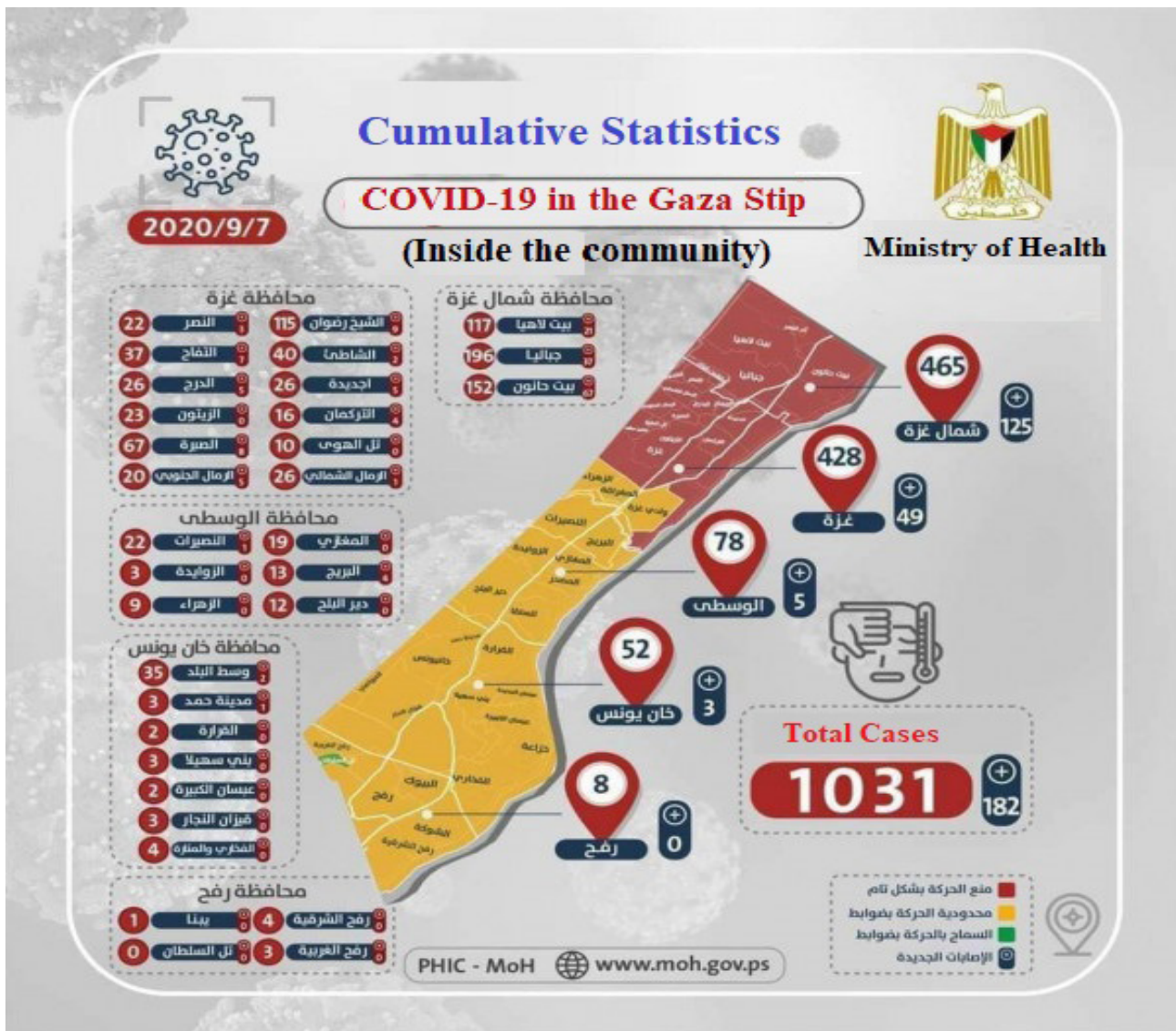
Introduction

The COVID-19 pandemic is a global public health threat of serious concern especially in conflict settings that face fragility and lack adequate resources and capacities. The Gaza Strip is a 365-km² strip of land at the coast of the Mediterranean Sea that has been under Israeli occupation for 53 years. It suffers from a blockade imposed by the occupation, environmental deterioration, confiscation of lands, demolition of houses and hospitals, restrictions on movement, lack of control over natural resources, and financial constraints. Gaza's population is consequently living in a poor humanitarian situation with high rates of unemployment, poverty, overcrowdedness, and a weak health system. This makes Gaza particularly fragile and affects its ability to effectively respond to the COVID-19 pandemic. Despite the Geneva Convention requiring the occupying power to take "prophylactic and preventive measures necessary to combat the spread of contagious diseases and epidemics" [1], Israel's violations of human rights and international law have been increasing during the past few months of the crisis. The Israeli occupation has also impeded Palestinian efforts to combat COVID-19, including restricting the entry of essential materials needed for the environmental and health sectors such as equipment and medications via the Israeli-controlled Karm Abu Salem crossing, the main commercial crossing.

The socio-economic situation in Palestine has deteriorated throughout the years; unemployment and poverty levels are extremely high, reaching 51% and 53%, respectively [2]. The pandemic's repercussions are likely to have a profound impact on socio-economic conditions, possibly causing a collapse of the Strip and increase the potential for conflict [3]. The Palestinian economy has been affected by the lockdown measures as people lost their jobs and more are expected to become unemployed [4]. This deters the Palestinian Authority's ability to respond to the COVID-19 and deal with its fiscal consequences, including the inability to pay the health workforce's even though their wages were previously reduced, finance the national response actions, and secure people's essential needs. The Ministry of Labour (MoL) estimates that out of 130,000 registered workers, around 38,000 need urgent humanitarian assistance which is exacerbating food insecurity and will, as a result, deteriorate their livelihood and health. [5].

In addition, the intra-Palestinian division between the West Bank and the Gaza Strip has adversely affected the national response with problems in health system governance, financial and human resources, capacity and technologies, research, and coordination.

However, the current reactive response of local authorities in Gaza has been effective in combating COVID-19. The number of cases and fatalities was relatively low when compared to numbers in neighboring regions including in the West Bank and Egypt. This has been possible not only because all incoming travelers to Gaza via Israel and Egypt enter a 21-day mandatory quarantine in designated facilities, but also because entry and exit into Gaza is extremely limited due to the blockade. On 25 August 2020, the total number of infections was reported from inside quarantine centers for arrivals to Gaza stood at 109, including one death. This situation continued control lasted until that date, but when the first four infections were detected in the general population from Al-Maghazi refugee camp in central Gaza, the number of cases was increased significantly and on 8 September 2020 reached to 1031 cases, including 8 deaths. The map in Figure 1 herein shows the total number of COVID-19 cases in the Gaza Strip, including the distribution of the cases on its five governorates.



(Figure1. Source:

<http://www.moh.gov.ps/portal/الم-مركز-19-كوفيد-لغفروس-التقرير-اليومي-لغفروس-كوفيد-19-مركز-الم>

Following the onset of the pandemic, institutions working in environmental and public health sectors from the Palestinian government, NGOs, and foreign agencies have given special attention to ensure the safe and sufficient provision of WASH services to protect public health. However, the pandemic is expected to make Gaza the worst-case scenario with respect to WASH-related diseases and deepen the fragility of Gaza's environmental and health systems, which are already overstretched beyond their limits. Per thousand people, Gaza has only 1.3 hospital beds and only a total of 80 to 90 ventilators for the whole population. This paper provides an

overview of the status of environmental pollution in the Gaza Strip in light of the COVID-19 pandemic and its impacts on the health system and public health. This includes water, sanitation, and hygiene (WASH), solid waste management, soil degradation, coastal and marine pollution, air pollution, and climate change.

The evidence in this paper was gathered through two main data collection methods; a review of national, regional, and international English and Arabic reports, documents, statistics, and studies, and in-depth interviews with key national actors in the environmental and public health sectors.

The Impact of environmental pollution on public health in light of the COVID-19 pandemic

Information was gathered through literature review and in-depth interviews with related health and environmental Palestinian actors as presented below:

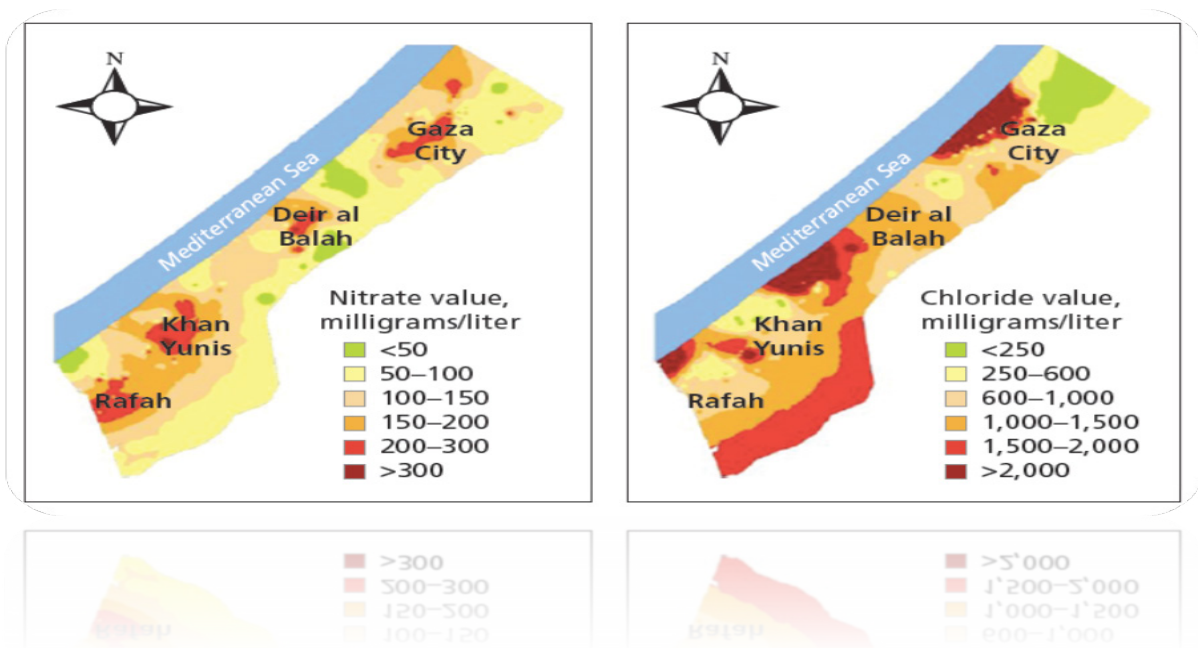
1.1 Findings of the literature review

1.1.1 Water, sanitation, and hygiene crisis

The availability of safe water, sanitation, and hygiene services are essential in preventing infectious diseases, including COVID-19. Hand washing is one of the most important measures to prevent COVID-19 infections [6]. However, the poor water quality, along with the deteriorating WASH infrastructure and services, continue to negatively impact the quality of life in the Gaza Strip and has numerous implications on public health [7, 8]. Moreover, according to the WHO, 97% of Gaza's groundwater, the main source of water in the Strip, is unfit for human use. The coastal aquifer in the Gaza Strip receives an annual average recharge of 55 to 60 million cubic meters (MCM/year), mainly from rainfall in addition to 30 MCM/year from lateral groundwater flow and leakages, while the annual intensive abstraction rate from the aquifer is about 200 MCM. As a result, it is estimated that there is an annual

cumulative water deficit of about 90 to 110 MCM/year. Therefore, the groundwater quality is deteriorating rapidly compared to WHO standards for drinking water with the high salinity of chloride concentrations that should not exceed 500 mg/l. The Palestinian Water Authority (PWA) and Coastal Municipalities Water Utility (CMWU) indicate the increase in nitrate concentrations with high salinity levels of 2000–10000 mg/l, high chloride concentrations of 500–3000 mg/l, and nitrate concentration of 100–800 mg/l especially in the northern part of Gaza. Additionally, according to the PWA, the per capita daily water consumption 88.3 liters per capita per day (lcd) in 2019 based on the records of the PWA, which is below the acceptable standard of 100 liters per capita per day that is recommended by the World Health Organization (WHO) [9, 10].

Figure 2 is a contour map of the nitrate and chloride contamination in Gaza's Coastal Aquifer.



(Figure 2. Source:

<https://www.semanticscholar.org/paper/The-Public-Health-Impacts-of-Gaza's-Water-Crisis%3A-Efron-Fischbach/a0524685d7ee634f894ed571314c33d3f0746b03>)

The chronic power shortages in Gaza are affecting the operation of healthcare institutions, wastewater treatment and desalination plants, water supply systems, and solid waste management facilities. Many sewage pumping stations are also at risk of flooding and pollution [11]. Compared to an estimated demand of 350 to 450 megawatts per day, the Gaza electricity grid supplies an average of 208 MW per day, from power stations in Israel, Gaza, and Egypt. Nevertheless, according to both optimistic and conservative scenarios, the difference between electricity demand and supply in Gaza is expected to increase in the coming years [12].

According to Efron 2019, one-fourth of all diseases in Gaza are waterborne [13]. Abuzerr's study in 2019 showed that the exposure to sewage that was collected around Gaza's neighborhoods was associated with an increased risk of acute diarrhea among children less than five. [14]. According to the WHO in 2016, WASH-related diseases accounted for over one-quarter of illnesses and are the primary cause of child morbidity in the Gaza Strip [8]. The chemical pollution of drinking water derives from its growing salinity and is a risk factor for hypertension and for intestinal diseases, which are particularly dangerous for babies, children, and pregnant women. The salinity of the water also corrodes metal pipes and raises the toxicity of the water due to high concentrations of heavy metals [15]. The biological pollution of drinking water, which derives from poor treatment of sewage, increases the frequency of intestinal infections from fecal sources. Among the most common diseases in Gaza are hepatitis A, typhoid fever, and meningitis caused by intestinal viruses, bacteria, and parasitic infections among kindergarten-age children [16]. Besides, there is a greater risk for the outbreak of diseases that represent a high risk to public health, such as polio and cholera [17]. In 2016, viral meningitis was identified as the most common infectious disease observed in children in Gaza. In 2011, 26% of all childhood diseases in Gaza were identified by UNICEF as waterborne.

People's inability to afford to pay for improved WASH services and products such as treated water, soap, disinfectants, or menstrual hygiene products, particularly during the COVID-19 pandemic, could also increase the

likelihood of further spreading WASH-borne diseases in Gaza [18, 19].

Consequently, this pandemic is expected to amplify the fragility of the already overstretched Palestinian health system and will hinder its capacity to deal with the pandemic and other preexisting health needs of Gaza's population.

1.1.2 Solid waste management crises

Solid waste management (SWM), including collection, transportation, and disposal, is among the most critical challenges facing service providers in the Gaza Strip. The total solid waste generation in Gaza is estimated at around 1,330 tons of waste per day, with a daily solid waste generation per capita of 0.7 kg/day [20]. On average, the generation rate in urban areas is double that in rural areas, which generate less than 0.5 kg/capita [21]. SWM services are provided by ten municipalities, along with joint services councils. Together, they employ about 1,200 workers and rely on about 500 donkey-pulled vehicles, 76 waste collection vehicles, and 23 other machines such as waste compression and loading machines.

In responding to the spread of the COVID-19, in April 2020 the Palestinian Environmental Quality Authority (EQA) issued a guidebook titled "A guide to maintaining public health, the environment, and solid waste management to limit the spread of COVID-19". It included containment measures to mitigate the spread of COVID-19 and information to educate workers and service providers about the safe collection and disposal of infectious waste generated in households as well as quarantine and isolation centers [22]. However, this waste is collected by the municipality employees themselves, disposed of in the same containers, and transferred to the same landfills as normal municipal solid waste. Additionally, there is no specialized system for the management of solid waste contaminated with infectious waste [23].

According to a recent assessment by the WASH Cluster, the collection of solid waste has been suspended for 30% of households in Gaza since late April,

especially those located on the margins of urban areas [24]. The average rate of municipal fee collection throughout Gaza declined from 22% in January 2020 to no more than 13% in April. To avoid a complete breakdown in services, on 28 April, the municipalities of Gaza have announced the scaling back of all municipal services, including SWM, as well as their inability to pay the wages of the solid waste workforce, which were already reduced previously. Municipalities were also forced to reduce funding allocated for the purchase of the fuel needed to run SWM vehicles and machinery [25]. Therefore, although the outbreak was contained in the first 5 months of the pandemic, solid waste is a potential source of transmission of this virus. See Figure 3 for a photo showing the Beit Lahia dumpsite in northern Gaza.



(Figure 3. Source:

[https://www.ochaopt.org/content/waste-away-living-next-dumpsite\)](https://www.ochaopt.org/content/waste-away-living-next-dumpsite)

1.1.3 Soil pollution

In the times of COVID-19, the immense electricity deficit affecting the Gaza Strip, alongside the longstanding shortage of adequate sanitation infrastructure, continues to result in the discharge of 100-108 million liters of poorly treated sewage into the sea every day [26].

This situation poses serious health and environmental hazards, particularly soils along the Wadi Gaza bed and beach sands [27]. In Gaza, the annual rate for the use of agricultural fertilizers and pesticides reached 12,000 and 893.3 tons, respectively, including about 160 brands, 19 of which are internationally banned for their short and long-term adverse health effects [28].

The months later the outbreak witnessed uncontrolled agricultural activities including the uncontrolled use of chemical fertilizers and pesticides causing soil pollution and severe risks to human health.

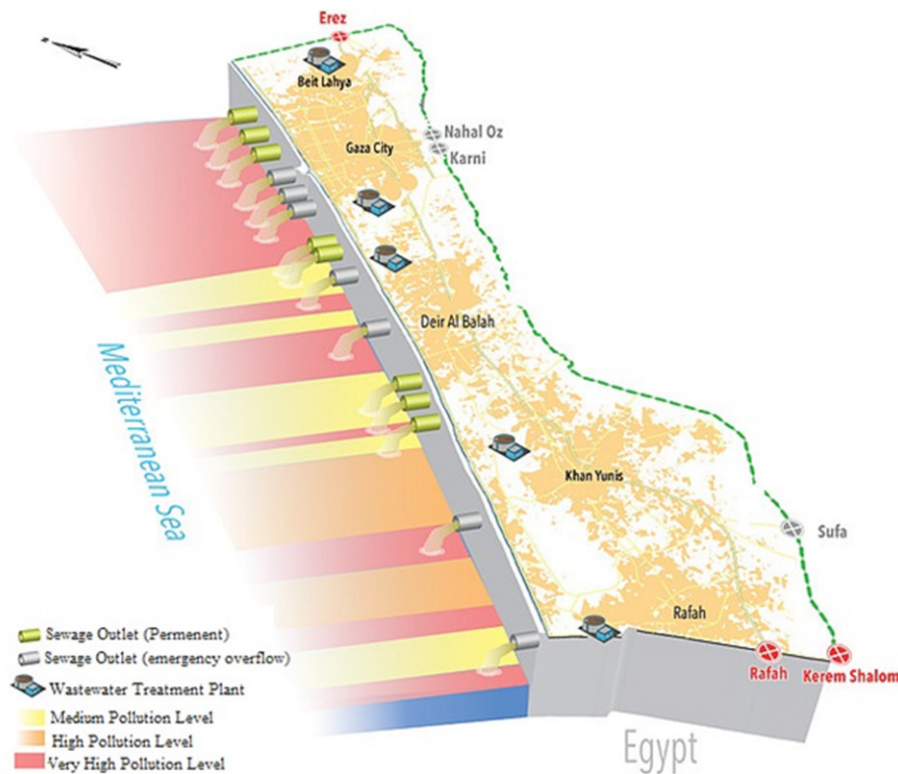
For the past few years, the Israeli army has been intensified its aerial spraying of chemical herbicides on farmlands in Gaza in the so-called “buffer zone” or Access Restricted Areas (ARA) bordering Israel, in the process destroying lands and crops under the pretext of security. Thus, under the pretext of “security”, Israel is waging an undeclared economic and chemical war against the people in the Gaza Strip, which has serious medium and long-term consequences as well as a direct threat to the public health, environment, soil, and livestock [29]. This chemical spraying was not halted even during the COVID-19 pandemic as Israeli planes conducted an extensive aerial spraying campaign on Gazan farmlands in early April 2020.

Furthermore, since 2008, Gaza has witnessed three devastating wars, during which Israel bombed Gaza with heavy missiles and rockets causing extensive and long-term damage to soil and its physical, chemical, and biological characteristics needed for agriculture. Agricultural lands in the northern and eastern border regions are constantly exposed to Israeli incursions by tanks and heavy machinery under heavy fire causing soil compaction. Accordingly, soil compaction leads to soil infertility by decreasing the

ability of water and air to permeate the compacted soil [30]. The risks of radioactive materials from repeated Israeli bombardment on Gaza cannot be ignored. For instance, uranium and heavy metals like mercury, lead, and arsenic are causing soil pollution and lead to numerous diseases including damage to brain tissue, muscle weakness, diseases in the digestive system, liver disorders, and growth disorders [31].

1.1.4 Coastal and marine pollution

The immense electricity deficit affecting the Gaza Strip, alongside the longstanding shortage of adequate sanitation infrastructure, continues to result in the discharge of 100-108 million liters of poorly treated sewage into the sea every day. Figure 4 is a map showing the locations of estuary sewers along the shores of Gaza. An additional 20 million liters of sewage seeps to groundwater from household cesspits. The precarious nature of these facilities also generates a constant threat of sewage flooding in areas adjacent to reservoirs and pumping stations. This situation poses serious health and environmental hazards, particularly during the summer when swimming in the sea is one of the few recreational activities available to people in Gaza. The reported seawater contamination was nearly four times higher than the environmental health standard by the United States Environmental Protection Agency (EPA). Research showed that the greater the concentrations of fecal bacteria in seawater polluted by sewage, the greater the risk of gastrointestinal infections, as well as skin diseases and eye and ear infections, especially among children, the elderly, and people with weak immune systems [32].



(Figure 4. Source:

<https://www.ochaopt.org/content/seawater-pollution-raises-concerns-waterborne-diseases-and-environmental-hazards-gaza-strip>)

Sewage outflows from Gaza also have adverse effects on marine life, fishing, coastal biodiversity, and ecological and human well-being. On 19 March 2020, the WHO published a guidance document on water, sanitation, hygiene, and waste management for the time of the COVID-19 virus [33]. The WHO reported that up to date there was no evidence for the survival of the COVID-19 virus in drinking water or sewage. Nonetheless, the WHO advised to “manage excreta (feces and urine) safely, including ensuring that no one comes into contact with it and that it is treated and disposed of correctly”. Recent studies suggest that COVID-19 may be transmitted also through human waste [34]. Also, a recent study in China suggests that diarrhea may be a secondary way of transmitting the virus [35]. Thus, the discharge of sewage every day into the Mediterranean Sea creates public health issues, especially during the COVID-19 pandemic as the fact that non-transmission of COVID-19 through the sewage has not yet been proven [36].

1.1.5 Air pollution and climate change

Although the epidemiology of COVID-19 is evolving, there is a significant correlation between causes of death in COVID-19 patients and the conditions caused and/or exacerbated by long-term exposure to fine particulate matter 2.5 micrometers (PM 2.5) [37]. In Gaza, the issue of air pollution is attributed to the density of motor vehicles, estimated at 60,000, including a high number of old vehicles. Also, large quantities of harmful toxic gases produced by Israeli factories, especially from coal-fired power plants located in Ashdod and Ashkelon near the border with Gaza are carried to the Strip by the wind. If we look at the effects of the unjust siege on the environment of the Gaza Strip, we find shocking facts about air pollution. Toxic gases, including sulfur dioxide and carbon monoxide, which harm the respiratory system, are released into the air due to the use of home generators. These are used extensively in Gaza to compensate for the shortage in electricity supply resulting from Gaza's inability to run its power plant full-time. It is estimated that there are about 100,000 of these generators in use and that they consume about 500,000 liters of fuel per day [38].

1.2 In-depth interviews findings

In-depth interviews were conducted with six representatives of related Palestinian governmental institutions and NGOs. The experts were asked about their views and perceptions regarding the impact of environmental pollution on health in Gaza in light of the spread of the COVID-19 pandemic.

Water, sanitation, and hygiene (WASH) crisis:

Ensuring proper, safe, and sufficient provision of WASH services is a fundamental human right, particularly during the existing COVID-19 emergency where WASH plays a crucial role in disease containment and public health protection. In the Gaza Strip, WASH services are already affected by the depleted water resources, the prolonged siege, and the

growing demand due to population growth. These conditions continue to make Gaza the worst-case scenario with respect to WASH-related diseases.

Based on the WHO guidelines, the risk for COVID-19 transmission through water is low, however, if any contamination with COVID-19 through feces occurred, the virus can remain infectious for weeks. Therefore, Palestinian authorities are working to ensure water safety, at least, via maintaining the disinfection of water supplies. Besides, the authorities are trying to meet the growing demand for water supply and the subsequent increase in the produced wastewater by investing in non-conventional water resources projects such as seawater desalination.

Eng. Reem Abu Shomar, Program Coordination Unit, Palestinian Water Authority (PWA), and Eng. Motaz Abo Al Qomboz, Head of the Design Department at the Coastal Municipalities Water Utility (CMWU) talked about the current WASH status in the Gaza Strip:

“... The main concern is to ensure continuous access to safe drinking water and sanitation, despite increasing restrictions, to minimize the impact of COVID-19. Current needs identified by the Palestinian Water Authority (PWA) and other service providers, to ensure cleaning and disinfection of WASH facilities include the procurement of calcium hypochlorite and other sterilization materials, are for an initial cost of approximately \$188,000, and the rehabilitation of key WASH facilities.” Eng. Reem Abu Shomar, said.

“... The containment measures of the COVID-19 pandemic have put an additional burden on WASH cluster partners. Since the onset of the pandemic, more water quantities are demanded to ensure hygiene practices at the household level and infection prevention control at healthcare facilities when compared to the prior COVID-19 era. More attention was given to ensure the provision of WASH services and new procedures have been adopted for the disinfection and dumping of trucked wastewater in the allocated dumping sites to reduce the risk of spreading COVID-19, particularly wastewater from quarantine centers. However, Israel is largely restricting the number of WASH supplies entering the Gaza Strip. This lack of safe WASH services

raises public health concerns and increases the risk of spreading COVID-19 infection among the population in Gaza.” Eng. Motaz Abo Al Qomboz, said.

Solid waste management (SWM) crisis:

Since the outbreak of COVID-19, the situation of SWM has further deteriorated due to worsening economic conditions and the shrinkage of resources available to service providers. It can also be attributed to additional risks posed by the need to manage increased quantities of infectious waste and the deficit is expected to increase as a result of the COVID-19 pandemic.

The director of the Joint Service Council for Solid Waste Management in Gaza Strip, Dr. Ali Barhoum, and Eng. Samir Matar, from the Municipal Development and Lending Fund, summarized most of the key factors affecting the SWM sector during the COVID-19 pandemic in the Gaza Strip:

“...Concurrently with the declaration of the Palestinian Government of the State of Emergency when the first positive case of COVID-19 was diagnosed on 5 March 2020, we noticed that the generation of solid waste was increased by about 20% in March and April 2020. Training of solid waste workforces on infection control measures was conducted, providing them with personal protective equipment as well as disinfection and sterilization materials for personnel and vehicles entering and leaving quarantine premises. Every day, almost 3-4 tons of solid waste is collected from quarantine centers in the Gaza Strip. These wastes are disposed of in a designated area neighboring landfills. The COVID-19 pandemic led to an extra financial burden on the council which faces chronic financial crises due to significant funding cuts and the severe shortage of equipment and essential supplies, that threaten public health and increases the risk of spreading COVID-19 infection in the community.” Dr. Ali Barhoum, said.

“... In reality, SWM continues to be seen as a serious environmental and human health concern in the Gaza Strip resulting from the accumulation of tons of uncollected trash in some areas. Residents of these areas report

that the smell intensifies as temperatures rise, with the air becoming toxic, compounded by outbreaks of flash fires and smoke. The accumulated trash also attracts stray dogs and cats, as well as rodents – all possible vectors of diseases-, which has become an increasing safety concern, especially for children. Consequently, even though the outbreak was contained in the first 5 months of the pandemic, solid waste is a potential source of contagion.” Eng. Samir Matar, said.

The burden on the health system during COVID-19 pandemic:

The capacity and resources of a health system play a major role in its ability to prepare and respond to emergencies. Successive governments have underinvested in the health system in Palestine over many years. This system is highly fragmented, under-resourced, largely strained, and donor-dependent, which in turn increases shortages of advanced infrastructure, technologies, and sufficient supplies especially during this outbreak.

The members of the Central Committee for Infection Control at the Ministry of Health in Gaza, Dr. Rami Al Abadla and Dr. Majdi Dohair, explained the major gaps in the health system during the COVID-19 pandemic:

“... So far, the number of confirmed cases of COVID-19 is still small, a total of 109 cases, all of which were subjected to a mandatory quarantine under several major challenges which are increasing the threat of COVID-19 infection in Gaza, including 1) overstretched the healthcare system; 2) inadequate access to safe water, sanitation, and hygiene (WASH) services, which are essential for infection prevention, particularly in quarantine centers. However, the concern over a severe spike of cases remains and the numbers are expected to rise exponentially and therefore it is imperative to start thinking strategically on what can realistically be done before we lose control over the current situation. The virus could rampage through the Palestinian population of nearly two million, the majority of whom live in tightly packed refugee camps. Gaza’s health infrastructure, crippled by an Israeli blockade and further damaged in the war, will be unable to cope

with the worst-case scenario wherein tens of thousands of people require hospitalization when there are only 2,500 beds available. A catastrophe of massive proportions could await Palestinians in Gaza who already have suffered far too much. Hence, in the case of COVID-19, Israel should ease the blockade to let in hygiene kits, ventilators, and other supplies, and suspend the requirement for transit permits for those who require hospitalization outside of Gaza. It should also support international efforts to erect field hospitals in and around the Gaza Strip, facilitate the entry of medical personnel willing to volunteer their services, and develop a plan for treating Palestinians from Gaza who need urgent medical attention outside Gaza.” Dr. Rami Al Abadla, said on 21 August 2020.

“... In the Gaza Strip, only 17 out of the 52 primary healthcare centers are functioning and two health centers have been converted to quarantine centers. Four hundred doctors, nurses, and administrative staff were mobilized to support quarantine centers. Meanwhile, breast cancer screening has stopped and is limited only to diagnostic services. Routine NCD patient care has also been postponed, in addition to early child growth and development services, oral and dental health services, and physiotherapy. All hospitals in Gaza have postponed elective surgeries and outpatient services. 4,000 elective surgeries (in addition to over 8,000 existing cases) have been postponed due to preparedness measures for possible management of COVID-19 cases. Also, the Israeli occupation is crippling various preparedness and response measures. The lack of electricity, WASH services, and medical supplies also interrupt the continuity of service provision to people who are in quarantine centers, which means that public health facilities’ ability to adhere to advised WASH protocols in the fight against COVID-19 will be deterred. Accordingly, the pandemic is expected to deepen the fragility of the Palestinian health system in the Gaza Strip. This will increase the burden on hospitals in coping with more cases of COVID-19 and hinder its capacity to deal with the pandemic and will likely be an almost insurmountable challenge.” Dr. Majdi Dohair, said.

Conclusions and recommendations

The COVID-19 pandemic is a serious environmental and public health concern worldwide, particularly in conflict settings such as the Gaza Strip, which face fragility, weak governance, and significant deficits in resources. The 14-year ongoing Israeli siege on Gaza is causing a dire humanitarian situation as the COVID-19 crisis has revealed major issues in environmental and health systems. Hence, the pandemic is an opportunity for governments, decision-makers, and donors to address these humanitarian difficulties in order to ensure the full enjoyment of basic human rights for the civilian population in the occupied Palestinian territory, particularly in Gaza.

In order to mitigate the impact of environmental pollution on public health in light of the COVID-19 pandemic in the Gaza Strip, the following recommendations were proposed by the stakeholders in the webinar held to discuss the findings of this report:

1. All local and international human rights and advocacy organizations are invited to put pressure to immediately end Israel's closure on the Gaza Strip that is causing a serious shortage of medical supplies, environmental infrastructure, humanitarian needs, and fuel in compliance with international humanitarian

law and the provisions of the Israeli Palestinian Agreement on Movement and Access of November 2005;

2. Urging donor countries and international health and environmental organizations to continue their efforts to ensure the provision of necessary political and financial support to the establishment of seawater desalination and wastewater treatment plants in the Gaza Strip and providing them with sufficient energy.
3. Further coordinated efforts between the different Palestinian environmental and health actors are needed to develop a national strategy towards the implementation of sustainable environmental and health development.

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