THE EFFECT OF TOXINS ON CLIMATIC CHANGES AND TRAVEL MEDICINE

Enas A. El Saftawy[1,2]; Ahmed Hamdy Elsayed Badr[3,4]; Amani Abdel Fattah[5]. Dena Mohamed Naguib Abdel Moawed[6,7]; Fatma Nada Khalifa[5,7]

[1]Medical Parasitology Department, Faculty of Medicine, Cairo University, Cairo, Egypt
[2]Medical Parasitology Department, Armed Forces College of Medicine, Cairo, Egypt
[3]Microbiology Department, Military Medical Academy, Cairo, Egypt
[4]Egypt Center for Research and Regenerative Medicine, Cairo, Egypt
[5]Forensic Medicine and Clinical Toxicology Department, Kasralainy, Cairo University
[6]Forensic Medicine and Clinical Toxicology Department, Zagazig University
[7]Forensic Medicine and Clinical Toxicology Department, Badr University in Cairo, BUC

Corresponding Author: Dena Mohamed Naguib Abdel Moawed
Email address: drdondon.dm@gmail.com
Submit Date 2023-08-04.
Revise Date 2024-01-16.
Accept Date 2024-02-16.

ABSTRACT

Background: Global climate change (GCC) is on the point of altering the degree of human exposure to poisons and the response of hominoid populations to these contacts, meaning that risks of pollutants could change in the future. In certain parts of the world, GCC is foretold to increase the level of exposure to many environmental contaminants due to direct and indirect belongings on the use designs and transport, and destiny of chemicals. Changes in human performance will also affect human contact way with contaminated air, water, and food. Psychosocial stress, dietary changes, and contact with stressors as high temperatures are likely to increase the susceptibility of humans to chemicals. These changes are likely to have important inferences for current practices for chemical assessment. Traditions used in current exposure-assessment replicas may no longer apply, and existing checking methods may not be vigorous enough to detect adverse sporadic changes in exposures. **Aim of the work:** The present review article explores how GCC might touch the different ladders in the pathway from a chemical source in the environment through to impacts on human health and assesses the proposals for current risk assessment and management practices. **Methodology:** Articles were assembled using convenient keywords through Google Scholar, PubMed, Egyptian Knowledge Bank (EKB), Wiley Online Library, and Web of Science. Inclusion criteria: peer-reviewed studies, meta-analytic and narrative reviews, and WHO reports published in the era between 1995 and 2022. Exclusion criteria: online articles not allied to a committed database or articles with closed access. **Results:** more research and studies are needed for prevention GCC

Keywords: Toxicology, Exposure pathway, Risk assessment, Vulnerability

INTRODUCTION

Global climate change (GCC) is linked to significant changes in long-term climate features and short-term climate excesses in different areas. The domain is flattering heater, with upsurges in temperature being highest over land and at high north latitudes, and minimum over the Southern Ocean. The snow-shelter area is constricting, and sea and highland ice are shrinking. Rainfall has enlarged in many areas at higher latitudes, while reductions have been experiential in most subtropical land areas. These trends are expected to continue and strengthen into the probable future **(Balbus et al 2013).**

The present review article aims to highlight the different ladders in the pathway from a chemical source in the environment to effects on human health and assesses the proposals for current risk assessment and management practices.

METHODOLOGY

To yield a protocol for the current work on toxic pollutants that affect climate and travel medicine we explored these questions: (i) What are the pollutants that do have toxic potential? (ii) How do the resultant climatic alterations influence the epidemiology of the diseases? The different efforts spent to re-engineer climate conditions and what are the obstacles that hinder successful results? To what extent guide for travel medicine be modified? Then, the draft framework was revised by the authors until we got a final settlement. Articles were assembled using convenient keywords through Google Scholar, PubMed, Egyptian Knowledge Bank (EKB), Wiley Online Library, and Web of Science. Inclusion criteria: peer-reviewed studies, meta-analytic and narrative reviews, and WHO reports published in the era between 1995 and 2022. Exclusion criteria: online articles not allied to a committed database or articles with closed access.

What is Climate toxicology?

Contact with the smoke made by wildfires, and the toxic chemicals formed from pyrolysis that persist in the remains, stance weighty dangers for human well-being. The most toxic mechanisms of fire smoke contain carbon monoxide, which deteriorates cardiorespiratory disease and harmfully affects brain function, while fire debris shelters high levels of toxic metals and insistent organic pollutants **(September 24, 2019, https://www.openaccessgovernment.org/category/open-access-news/environment-news/).**

According to a popular notion, increasing body temperature stimulates the activity of enzymes involved in the metabolism of harmful compounds, some of which help to reduce the toxicity of the chemical while others help to detoxify it. Another clarification comes from experimental and epidemiological research that shows how the impact of harmful substances is exacerbated by persistent stress. There is ample evidence that the GCC raises pressure, particularly among populations that are facing food or water insecurity or that have been forced to flee due to climatic catastrophes **(White and Walcott et al 2009).**

What is the chemical toxicity of GCC?

Chemical pollutants in the environment have both direct and indirect effects on human health. Direct toxic effects range from acute poisonings and activating of acute events like cardiac arrhythmias and asthma to chronic effects like immunosuppression and cancer **(Belpomme et al 2007 and D'Amato et al 2005)**. Indirect effects contain changes in health risks associated with changes in food and water sources as a result of chemical pollution or due to antibiotic resistance in bacteria exposed to toxic chemicals **(Baker-Austin et al 2006)**. In a U.K. study, **(Beulke et al 2007)** figured out how to measure how changes in pesticide use, fate, and transport—caused either directly or indirectly by GCC—affect surface water and groundwater concentrations. According to the study, peak pesticide concentrations may increase by many orders of magnitude for some pesticides in surface waters and groundwaters under GCC. Researchers found that the GCC's indirect effects on surface-water exposure (i.e., its influences on pesticide application volume and timing) were greater than the effects of changes in climate alone **(Cecchi et al 2010)**.

Changes in these processes linked to GCC have an impact on human exposures since the permanence and adaptability of harmful chemicals in the environment are influenced by weather variables like temperature and wind **(Gaze et al 2011)**.

GCC will have an impact also on the way of using these resources by people, with implications on the quality of human contact. As human populations shift to new sources of drinking water (such as water from water reuse and reclamation systems), a decline in the availability of water for many populations could modify exposure to marine contaminants. Variations in climate may also affect how much time people spend inside and outside houses, affecting their exposure to both external and internal toxins **(Cecchi et al 2010)**.

What are the health effects of environmental exposures affected by GCC?

Health effects due to some environmental exposures are documented to be exaggerated by GCC **(Balbus et al 2013):** Mycotoxins which are good residues like aflatoxins cause carcinogenicity, hepatotoxicity, immune-suppression, and developmental toxicity. Ozone causes lung problems such as asthma exacerbation and chronic pulmonary obstructive disease. Methyl mercury causes neurotoxicity. Biphenyls and dioxins cause reproductive and endocrine toxicity and carcinogenicity.

Does GCC impact human susceptibility?

In **Balbus et al (2013)** study, he showed that GCC could have an optimistic result on experience, in most occurrences an opposing effect is expected in convinced regions, and it is likely that this will adversely affect the health. Additionally, samples of numerous health impacts and risks for particular chemical encounters are probably going to be jammed by GCC. It demonstrates how the GCC affects the sporadic incidence and occurrence of acute events, such as cardiovascular and respiratory illnesses in people caused by episodes of high air pollution. Increased algal and mycological invasion episodes in developing nations are likely to represent increased mycotoxin exposures, which will likely result in an increased incidence of cancer and target organ toxicity **(Tirado et al 2010, Armitage et al 2011 and Magan et al 2011)**.

There has been a partial study of the consequence of temperature on the poisonousness of chemicals in animal models. The temperature has been observed to upsurge neurotoxicity from methamphetamine exposures in mice **(Miller and O'Callaghan 2003)**, and in general, increasing temperature worsens chemical poisonousness in animal models (**Gordon 2003)**. Numerous non-chemical stresses, including some pre-existing infectious and non-infectious disorders, exposure to violence, and other psychosocial stressors have been shown to modify chemical toxicity **(Krewski et al 2005 and Shankardass et al 2007).** Changes in the food chain structure are likely to result in dietary changes that affect nutritional status **(Lake et al 2012)**. Violence and other social and societal repercussions of heat are among the psychosocial effects of GCC **(Doherty and Clayton, 2011).**

What are the impacts of GCC on chemical risk assessment of major toxic pollutants?

1. Natural toxins

Natural toxins contain toxins that are produced by algae, bacteria, plants, and fungi. These toxins have been reported to cause human health effects, including death, growth disturbance, and cancer. Natural toxin production is affected by environmental factors like temperature and humidity. Also, GCC affects the insect vectors' activity and so increases human exposure to phytotoxins and mycotoxins **(Miraglia et al., 2009).**

Human exposure to natural toxins is controlled through monitoring of concentrations of these compounds in crops, shellfish, and drinking water. Therefore, any effect of GCC on the occurrence and toxicity of natural toxins to humans will be of direct interest to regulatory and public health agencies responsible for monitoring these compounds and to suppliers of food or drinking water **(Fawell and Nieuwenhuijsen, 2003; Paterson and Lima, 2010).**

2. Pesticides

Pesticides are widely used in agriculture in many parts of the world. They are vital agents in vector control around the world. It is anticipated that pesticide use will increase with increasing temperature due to greater pest activity **(Boxall et al., 2009).**

It has both short- and long-term health effects. Efforts to decrease human exposure to pesticides target three levels: pesticide residues in food and drinking water; exposures in farmers; and lastly community exposures. Setting pesticide residue–tolerance levels in foods is the main regulatory activity to protect the safety of the food supply **(International Programme on Chemical Safety (IPCS) Geneva 2009).**

Follow-up of workers who are vulnerable to the effects of pesticides by enhanced skin absorption is also important. Monitoring for pesticide residues is needed to ensure a safe food supply and new product registrations are based on regulatory risk assessments **(Balbus et al., 2013).**

3. Air pollutants

Human activities such as fuel combustion and natural processes like wildfires cause the release of many toxic pollutants into the air. The two most important air pollutants associated with serious health effects are fine particulate matter and ozone. In the United States, it has been estimated about 130,000 deaths by fine particulate materials and about 4,700 deaths by ozone in 2005. These pollutants are largely affected by weather conditions. Fine particulate matters increase in windy weather. Ozone concentrations are higher with high temperatures **(Balbus et al., 2013).**

Health effects associated with both air pollutants include the exacerbation of chronic lung disease, asthma, and myocardial infarction. In addition, non-chemical stressors of GCC may change the vulnerability of humans to toxic insults. High ozone levels and high temperatures are associated with increased cardiovascular mortality **(Ketinge et al., 2000; Carriero et al., 2002).**

Human health effects caused by air pollutants are managed by regulatory standards for ambient air concentrations and by emissions-control standards for specific sources. Air-quality models include assumptions about weather conditions to determine critical model parameters that control air pollution concentration measures. As GCC progresses, these models will need to be revised to reflect changes in temperature and precipitation **(Balbus et al., 2013).**

Measures for the reduction of greenhouse gases as the development of alternative fuels would cause a reduction in these air pollutants **(Tsao et al., 2012).**

4. Legacy pollutants

Legacy pollutants are obstinate substances that have been amassed in environmental pools such as surface soils, ice, residues, and forests **(Scheringer 1997)** and **(Conner et al 2007).** Their slow and continuous emissions pose a lasting risk to human people and ecosystem health **(Cowan-Ellsberry 2007).** Dioxins and dioxin-like compounds, mercury discharged into the environment during extraction and burning, radioactive chemicals from nuclear weapons testing, DDT, lindane, and other pollutants are examples of legacy pollutants **(McKone et al. 2004)**. These pollutants have a variety of health effects, including cancer, poor reproductive outcomes, and altered neurodevelopment. The control of legacy pollutants, in contrast to the other concerns outlined in the current study, mostly entails identifying reservoir sources and justifying exposure rather than managing or lowering emissions from continuing economic/industrial activity **(Gouin, 2007).** The inhabitants of developing countries may be particularly exposed because of ongoing recycling and waste-processing activities, as well as the frequent absence of appropriate monitoring and control of legacy pollutant overflow sites **(Linderholm 2011)**.

Because legacy pollutants accumulate in the environment, longer-term environmental processes related to GCC could affect their fate and change human and ecological system exposures **(MacLeod 2005)**. Classification of the persistence and spatial range of organic chemical environmental distribution behavior. Regional and worldwide migration patterns will change if GCC results in stronger winds and/or stronger rivers, lakes, estuaries, and ocean currents. **(Balbus et al 2013)**, will be vital.

It is important to understand that changing climates contributed to the collapse of ancient civilizations due to soil–climate interactions that degraded soil and affected related economies **(Brevik et al 2018)**. The collapse of the Harappan, Tiwanaku, Akkadian, Classic Maya, and Mochica civilizations demonstrated the profound influence of climate change on humanity **(Wiener 2014)**.

However, the negative impacts of these climatic deviations on infectious diseases are largely underestimated. There is a long list of diseases that increased associating changes in climates involving Bovine spongiform encephalopathy, cysticercosis, dengue fever, diphtheria, the Hendra virus, group-B streptococcus, hepatitis C, histoplasmosis, influenza, and Ebola hemorrhagic fever MRSA, Nipah virus, norovirus, pertussis, plague, poliomyelitis, rabies, leptospirosis, leptospirosis, Lyme disease, malaria, measles, monkeypox, Shigellosis, Trypanosomiasis, smallpox, TB, tularemia, rotavirus, salmonellosis, severe acute respiratory syndrome, and rift valley fever. Besides, evidence of drug-resistant pathogen strains, water-borne, insect-borne, foodborne, and airborne diseases all increased **(Smith et al 2015)**. Seriously, in childhood, morbidity (34%) and mortality (36%) notably increased due to infectious agents on top of changes in environmental factors **(Thompson et al 2012)**. Therefore, we are asking if climatic changes can be considered a challenge for travel.

May climatic changes re-map tourism destinations?

According to WHO, climatic changes resulted in health hazards, disruption of the soil and aquatic ecosystems, limitation of food resources, and migrations of humans and animals **(WHO 2017)**. Thus, the prevalence, persistence, morbidity, and mortality due to infectious agents and their vectors increased such as malaria, and diarrhea **(Smith et al 2015)**. Unfortunately, poor countries are the most prone despite being the least responsible for the greenhouse effect due to CO2 emission **(Dhimal et al 2015a)**.

How did climate change affect arthropod-borne diseases?

The emergence of arthropod-borne diseases expanded to new regions due to global warming **(Cann et al 2013)** and outbreaks became prevalent in even high-income countries **(Semenza and Ebi 2019).** Notably, the effect of climatic changes on the vectors is not equal; for instance, increases in temperature, wind intensity, relative humidity, and rainfalls are convenient for mosquitoes' life cycle, not ticks **(Sanyaolu et al 2016)**.

- **Plasmodium sp.** It is the most lethal blood parasitic infection worldwide with nearly 500.000 deaths in Africa. Historically, Europe was attacked by malaria several times (Micallef 2016), that however was terminated in Europe in 1975 (Talapko et al 2019) following a malaria eradication program conducted by the WHO. The program encompassed seventy-nine countries (Askling et al 2012 and Caminade et al 2014). Yet, the re-introduction of malaria was reported in Croatia, Italy, Malta, Bulgaria, France, Germany, and Spain **(Monge-Maillo and López-Vélez 2012 and Medialdea Carrera et al 2018).** This might be attributed to the presence of the Anopheles vector present in Europe and the USA; thus, exerting a great threat to the reemerging of diseases at any due to climatic changes (Askling et al 2012 and Redshaw et al 2013).

- **Babesia spp. and Thelaria sp...** Due to the increased prevalence of ticks, babesiosis caused by Babesia microti, B. capreoli, and B. venatorum is progressively documented in Europe, Canada, and Japan **(Kulkarni et al 2015 and Lu et al 2016).** Also, the expansion of Dermacentor reticulatus in Europe and Eurasia increased infection with Theileria spp. **(Altizer et al 2013 and Földvári et al 2016).**
- **Leishmania and Trypanosoma.** In response to climatic changes, Phlebotomus species of Sandflies and Glossina tsetse flies were convicted respectively in the emergence of these blood flagellates in new locations **(Bern et al 2007, Nakazawa et al. 2007 and Redshaw et al. 2013).**
- **Trypanosoma brucei gambiense and T. brucei rhodesiense (African trypanosomiasis)** are transmitted by tsetse flies that show expansion in association with global warming and cause sleeping sickness. Infections are expected to expand to up to 30,000 people while 70 million individuals are at risk **(Moore et al 2012).** Besides, in Latin America, Trypanosoma cruzi which is transmitted by Triatoma infestans (kissing bugs) and causes Chagas disease expanded to Central and North America in at least 300,000 residents **(Shikanai-Yasuda and Carvalho 2012).**
- **Filaria spp.** Infections with these parasites increased in response to climatic changes, particularly Wuchereria bancrofti (agent of lymphatic filariasis, and elephantiasis) **(CDC 2013)** and Onchocerca volvulus (agent of river blindness) that are transmitted by Culex quinquefasciatus and blackflies respectively **(CDC 2020).**

Why should climatic changes implicate zoonosis in the guide of travel medicine?

Since ecosystem changes and several biological responses occurred in the pathogens such as species interactions, dispersal, evolution, and phenology **(Urban et al 2016)**, the ecological niches of zoonotic infections increased. For example, the filarial infection of Brugia pahangi coincides with the dynamics of Armigeres subalbatus mosquitoes in the plantation areas (**Intarapuk and Bhumiratana 2021**). Seriously, the Chikungunya (CHIKV) zoonotic arbovirus re-surged and underwent genetic mutation to infect the Asian tiger mosquito in addition to the mosquito of yellow fever **(Caminade et al 2017)**.

May climate change influence the dispersal of the microbiota systems in seashore and aquatic ecosystems?

This was recognized by the increases in bird populations on the seashore and the accumulation of microbiota like Salmonella, Campylobacter, and Chlamydia populations **(Navarro et al 2019)**. In addition, microbiota such as Staphylococcus, West Nile Virus, Aspergillus, and antibiotic-resistant strains of bacteria have been reported in gulls, barnacle geese, and terns. In addition, the global changes and people relocation and traveling harbored endemic allochthonous microbiota in the coastal areas particularly, in regions of desertification. Thus, the WHO recently recommended monitoring of the enterococci and fungi in the coastal sand **(Brandão et al 2022)** and several studies warned that the concentration of microbiota in beach sands increases the risk of several human health hazards **(Hubálek, 2021, Zeballos-Gross et al 2021 and Kurittu et al 2021)**.

Seriously, the lethal Naegleria fowleri (brain-eating amoeba), which causes primary amoebic meningoencephalitis and is characterized by being opportunistic and free-living protozoa were found to be increasingly existing. This amoeba is thermophilic, extensively present in temperatures beyond 30 °C with an upper limit of 45–46 °C, tolerable to a wide range of pH **(Herman et al 2021, Dos Santos et al 2022)**, and resistant to chlorination **(Miller et al 2015)**.

The snail vector of the Schistosoma haematobium was found to invade the East of Europe **(Majoros et al 2008)**; thus, the bilharzia or swimmer's itch expanded in this region (**Kolarova 2007**). In 2015, France witnessed an outbreak of schistosomiasis haematobium where the patients were from France Italy, and Germany **(Boissier et al 2015)**.

May melting ice uncover sleeping pathogens?

The CDC listed at least 50 emerging/re-emerging diseases. In Siberia, the Virola virus was discovered in a frozen mummy 300 old **(Biagini et al 2012)** and the emergence of resistant anthrax spores from the ice melt was also reported **(Antonenko et al 2013 and Mor et al 2018).** Moreover, spores of anthrax can be transported to remote areas by vectors such as tabanid flies. Thus, may the smallpox virus re-emerge from the frozen human cadavers buried in Siberia **(Antonenko et al 2013 and Mor et al 2018)**? In 2005, NASA documented that ice specimens from Alaska were composed of 32,000-year-old bacteria and incredibly, Antarctica contained 8-million-year-old bacteria hidden in ice **(Bidle et al 2007)**. Also, **Greenblatt et al (1999)** discovered bacteria in Dominican amber that returned 20- 40 million years ago.

May droughts increase incidences of resistant pathogens?

In drought, the diversity of microbial communities may increase in depleted waters **(O'Dwyer et al 2016)**. Drought may also enhance the habitat of Xero-tolerant opportunistic fungi Candida sp., which can favorably persist in dry sands **(Shah et al 2011)**. Also, **Moriyama et al (2020)** determined that drought triggered transmissions of influenza and coronavirus.

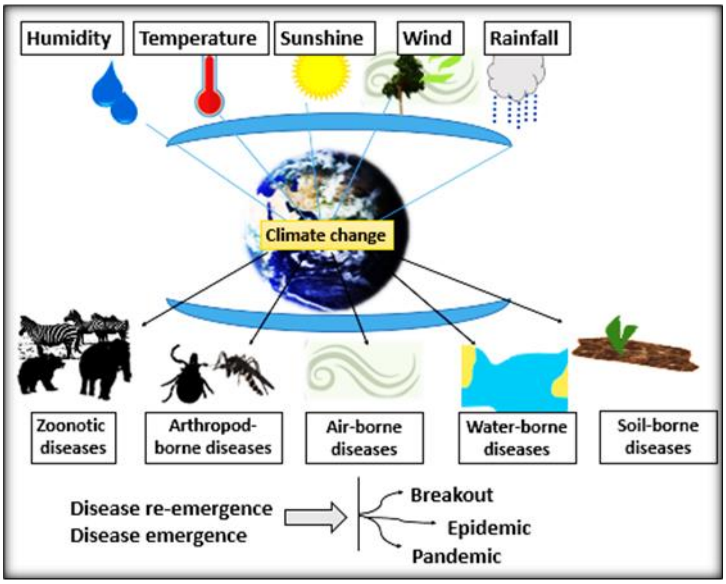

Figure (1): Climate change and its impact on pathogen expansion.

How could air increase play a role in disease transmission?

With increasing humidity, the lifetimes of the minute droplets extended; hence, were regarded as a cofactor in the COVID-19 pandemic **(Chong et al 2021)**. Air pollution increases the transmission of TB **(Asadgol et al 2019)**. Tourism played a role in the early transmission of COVID-19 in various countries; thus, constraining travel appeared to be an efficient strategy for preventing the spread of the disease **(Sadeghmoghadam et al 2020)**. Windpox and foot-and-mouth disease increased in humans and animals, respectively **(El-Sayed and Kamel, 2020)**.

What is Geoengineering or Climate Engineering?

To stop future climate change, slow down stop global warming, and lessen its consequences on our society and biosphere, the Earth's climate and environment must be deliberately altered on a huge scale **(Masson-Delmotte and colleagues, 2022).**

Humans have been changing our climate and environment for a long time, so geoengineering our climate is not a new concept. Since the 1960s, scientists have been researching and expressing concern about climate engineering **(Keith, 2000)**.

Natural climate solutions (such as ecosystem restoration and blue carbon, for example), solar radiation management, carbon dioxide removal, and a wide range of climate change adaptation and mitigation techniques are all included in geoengineering approaches.

Natural Climate Solutions:

In a Natural Climate Solution geoengineered restored forest ecosystem, trees play a crucial role in storing carbon within their trunks, branches, and leaves. As greeneries, sticks, and branches fall to the crushed from the forest canopy, they enrich the forest soils with organic matter, allowing vast quantities of carbon to be stored below ground. Reinstated forests also provide an environment for a wide variety of animals, which can help sequester carbon by storing it in their bodies. These animals include insects, frogs, lizards, and mammals. Additionally, forest ecosystems contain a complex network of organisms, such as protists, nematodes, earthworms, insects, reptiles, and mammals, that live within the soil and contribute to carbon sequestration. Over time, forest elements like insects, leaves, and dissolved organic carbon can enrich the waters of streams and rivers thanks to water runoff from forest ecosystems. These inputs give food to aquatic animals and plants, both of which trap carbon. **(Biodiversity & Services 2018)**.

In addition to carbon sequestration, Natural Climate Solutions can also help mitigate the effects of Climate Change and Global Warming by reflecting sunlight back into space. One such approach is cropland albedo enhancement, which uses crops to cool regional landscapes by reflecting sunlight back into space. This is achieved by selecting crop varieties that are more reflective and utilizing management techniques such as no-tillage, which increases the albedo of agricultural fields. By preventing the absorption of sunlight, crops can reduce the amount of heat that is generated, thus mitigating the effects of Climate Change and Global Warming **(Davin and de Noblet-Ducoudré 2010).**

Carbon dioxide removal (CDR):

This approach involves removing CO_2 from the atmosphere and storing it underground or in other long-term storage facilities. Some proposed CDR techniques include afforestation (planting trees to absorb CO_2), ocean fertilization (adding nutrients to the ocean to promote the growth of plankton, which absorb CO_2), and direct air capture (using machines to capture CO_2 directly from the air) **(Corry and Kornbech 2021).**

Proposed Carbon Dioxide Removal methodologies include:

By directly removing carbon dioxide from the air or atmosphere, Direct Air Capture techniques can either store the liquid CO_2 underground or use it to create carbon-neutral fuels or goods. Reducing the CO_2 emissions from coal power stations and other fossil fuel-based energy production facilities is the main goal of carbon capture and storage technologies. Methodologies for carbon capture and storage collect CO_2 during or after combustion and either store it underground or use it in carbon-neutral products **(Gür 2022)**.

By burying charcoal in the soil, biochar reduces atmospheric carbon dioxide as a response to global warming. Carbon dioxide is removed from the atmosphere by plants and trees. Then, using low oxygen levels, this plant matter, or biomass, is burned to create charcoal. After being ground into little particles, the charcoal is buried in agricultural fields' soil to trap carbon for hundreds of years **(Buss et al 2022)**.

Enhanced Weathering is a technique for removing carbon dioxide from the atmosphere through geoengineering. It involves using chemical reactions between rocks or minerals and CO_2 to decrease the amount of CO_2 in the atmosphere. To implement this method, rocks that contain silicate or carbonate, like olivine, are ground into a powder and mixed with agricultural soil or spread on beaches. When mixed with water and CO_2, the silicate rock powder reacts to form bicarbonate ions (HCO_3^-), which effectively reduces CO_2 in the atmosphere. The bicarbonate ions are then dissolved in water and eventually make their way to the ocean, where calcifying organisms like corals and plankton convert them to calcium carbonate ($CaCO_3$). This calcium carbonate eventually settles at the bottom of the ocean **(Goll et al 2021).**

Using planktonic communities, ocean fertilization is a method for removing CO_2 from the atmosphere. The growth of photosynthetic planktonic plants or algae is frequently constrained in sections of the ocean where upwelling occurs (as well as other areas of the ocean). By fertilizing these places, a lot of planktonic algae can grow and accumulate biomass by absorbing CO_2. The carbon dioxide the algae absorb gets eliminated from the atmosphere for incredibly long periods as they die and their biomass sinks to the ocean's bottom**.** This approach has been proposed as a way to mitigate climate change by removing

CO_2 from the atmosphere. However, there are concerns about its effectiveness and potential environmental impacts **(Bach et al 2021)**.

By storing the carbon in plants and animals, ecosystem restoration reduces the amount of carbon dioxide in the atmosphere. The Earth has lost a lot of its vegetation and has been damaged. Large volumes of carbon dioxide are absorbed and stored in the biomass of plants and animals when these ecological communities are recovered.

Blue Carbon Ecosystems: are a Natural Climate Solution that can help mitigate and reverse the impacts of Global Warming. These ecosystems are comprised of various coastal and marine communities, such as saltmarshes, seagrass meadows, mangrove forests, and kelp forests, which can absorb and store significant amounts of carbon in their tissues and soils. By conserving and restoring Blue Carbon Ecosystems, we can effectively remove large amounts of CO_2 from the atmosphere and store it for extended periods. Therefore, protecting and restoring these ecosystems can be an effective approach for mitigating the effects of Global Warming **(Nellemann et al 2010)**.

Solar radiation management (SRM):

This approach involves reflecting a portion of the sun's rays into space to reduce the amount of sunlight that reaches the Earth's surface. Some proposed SRM techniques include stratospheric aerosol injection (injecting reflective particles into the upper atmosphere), marine cloud brightening (spraying seawater into the air to create brighter clouds), and surface reflectivity modification (painting roofs and other surfaces with reflective materials) **(Ming et al., 2014).**

Enhanced weathering:

This approach involves accelerating the natural process of weathering, in which rocks react with CO_2 in the atmosphere to form stable minerals. Some proposed enhanced weathering techniques include spreading powdered rocks over land or ocean surfaces to increase weathering rates.

Bioenergy with carbon capture and storage (BECCS):

This approach involves using biomass (such as plants or agricultural waste) to generate energy, capturing the resulting CO_2 emissions, and storing them underground.

It's worth noting that while these techniques have been proposed, many of them are still in the experimental stages and have not yet been tested on a large scale. Additionally, there are concerns about the potential risks and unintended consequences of these approaches, which will need to be carefully studied and considered before their implementation.

Conflict of interests

The authors declare that there is no conflict of interest.

REFERENCES

Altizer, S., Ostfeld, R. S., Johnson, P. T., Kutz, S., & Harvell, C. D. (2013). Climate change and infectious diseases: from evidence to a predictive framework. science, 341(6145), 514-519.

Andreassen, A., Jore, S., Cuber, P., Dudman, S., Tengs, T., Isaksen, K., ... & Vainio, K. (2012). Prevalence of tick-borne encephalitis virus in tick nymphs in relation to climatic factors on the southern coast of Norway. Parasites & vectors, 5, 1-12.

Antonenko, Y. N., Khailova, L. S., Knorre, D. A., Markova, O. V., Rokitskaya, T. I., Ilyasova, T. M., ... & Skulachev, V. P. (2013). Penetrating cations enhance the uncoupling activity of anionic protonophores in mitochondria. PloS one, 8(4), e61902.

Armitage, J. M., Quinn, C. L., & Wania, F. (2011). Global climate change and contaminants—an overview of opportunities and priorities for modelling the potential implications for long-term human exposure to organic compounds in the Arctic. Journal of Environmental Monitoring, 13(6), 1532-1546.

Arora, P., Singh, P., Wang, Y., Yadav, A., Pawar, K., Singh, A., ... & Chowdhary, A. (2021). Environmental isolation of Candida auris from the coastal wetlands of Andaman Islands, India. MBio, 12(2), e03181-20.

Asadgol, Z., Mohammadi, H., Kermani, M., Badirzadeh, A., & Gholami, M. (2019). The effect of climate change on cholera disease: The road ahead using artificial neural network. PloS one, 14(11), e0224813.

Askling, H. H., Bruneel, F., Burchard, G., Castelli, F., Chiodini, P. L., Grobush, M. P., ... & Schlagenhauf, P. (2012). on behalf of the European Society for Clinical Microbiology and Infectious Diseases

Study Group on Clinical Parasitology: Management of imported malaria in Europe. Malar J, 11(1), 328.

Babaie, J., Barati, M., Azizi, M., Ephtekhari, A., & Sadat, S. J. (2018). Systematic evidence reviews of the effect of climate change on malaria in Iran. Journal of Parasitic Diseases, 42, 331-340.

Bach, L. T., Tamsitt, V., Gower, J., Hurd, C. L., Raven, J. A., & Boyd, P. W. (2021). Testing the climate intervention potential of ocean afforestation using the Great Atlantic Sargassum Belt. Nature Communications, 12(1), 2556.

Baker-Austin C, Wright MS, Stepanauskas R, McArthur JV. (2006). Coselection of antibiotic and metal resistance. Trends Microbiol.; 14:176–182.

Balbus, J. M., Boxall, A. B., Fenske, R. A., McKone, T. E., & Zeise, L. (2013). Implications of global climate change for the assessment and management of human health risks of chemicals in the natural environment. Environmental toxicology and chemistry, 32(1), 62-78.

Ballart, C., Barón, S., Alcover, M. M., Portús, M., & Gállego, M. (2012). Distribution of phlebotomine sand flies (Diptera: Psychodidae) in Andorra: first finding of P. perniciosus and wide distribution of P. ariasi. Acta tropica, 122(1), 155-159.

Bauer, S., & Hoye, B. J. (2014). Migratory animals couple biodiversity and ecosystem functioning worldwide. Science, 344(6179), 1242552.

Belpomme D, Irigaray P, Hardell L, Clapp R, Montagnier L, Epstein S, Sasco AJ. (2007). The multitude and diversity of environmental carcinogens. Environ Res.; 105:414–429. [PubMed] [Google Scholar]

Ben Ari, T., Gershunov, A., Gage, K. L., Snäll, T., Ettestad, P., Kausrud, K. L., & Stenseth, N. C. (2008). Human plague in the USA: the importance of regional and local climate. Biology Letters, 4(6), 737-740.

Bern, C., Montgomery, S. P., Herwaldt, B. L., Rassi, A., Marin-Neto, J. A., Dantas, R. O., ... & Moore, A. C. (2007). Evaluation and treatment of Chagas disease in the United States: a systematic review. Jama, 298(18), 2171-2181.

Beulke S, Boxall A, Brown C, Thomas M. 2007. Assessing and managing the impacts of climate change on the environmental risks of agricultural pathogens and contaminants: Pathways for transport of contaminants in agricultural systems and potential effects of climate change. Final report to Defra for project SD0441. Fera, Sand Hutton, York, UK.

Biagini, P., Thèves, C., Balaresque, P., Geraut, A., Cannet, C., Keyser, C., ... & Crubézy, E. (2012). Variola virus in a 300-year-old Siberian mummy. New England Journal of Medicine, 367(21), 2057-2059.

Bidle, K. D., Lee, S., Marchant, D. R., & Falkowski, P. G. (2007). Fossil genes and microbes in the oldest ice on Earth. Proceedings of the National Academy of Sciences, 104(33), 13455-13460.

Biodiversity, I. S.-P. P. o., & Services, E. (2018). The IPBES assessment report on land degradation and restoration. In: IPBES Secretariat Bonn, Germany.

Biswas, G., Sankara, D. P., Agua-Agum, J., & Maiga, A. (2013). Dracunculiasis (guinea worm disease): eradication without a drug or a vaccine. Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1623), 20120146.

Boecken, G., Sunderkötter, C., Bogdan, C., Weitzel, T., Fischer, M., Müller, A., ... & Erkens, K. (2011). Diagnosis and therapy of cutaneous and mucocutaneous Leishmaniasis in Germany. JDDG: Journal der Deutschen Dermatologischen Gesellschaft, 9, 1-51.

Boissier, J., Moné, H., Mitta, G., Bargues, M. D., Molyneux, D., & Mas-Coma, S. (2015). Schistosomiasis reaches Europe. The Lancet Infectious Diseases, 15(7), 757-758.

Boxall ABA, Hardy A, Beulke S, Boucard T, Burgin L, Falloon PD, Haygarth PM, Hutchinson T, Kovats RS, Leonardi G, Levy LS, Nichols G, Parsons SA, Potts L, Stone D, Topp E, Turley DB, Walsh K, Wellington EMH, Williams RJ (2009). Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture. Environ Health Perspect.; 117:508–514

Brandão, J., Weiskerger, C., Valério, E., Pitkänen, T., Meriläinen, P., Avolio, L., ... & Sadowsky, M. J. (2022). Climate Change Impacts on Microbiota in Beach Sand and Water: Looking Ahead. International journal of environmental research and public health, 19(3), 1444.

Brevik, E. C., Homburg, J. A., & Sandor, J. A. (2018). Soils, climate, and ancient civilizations. In Developments in Soil Science (Vol. 35, pp. 1-28). Elsevier.

Bright, K. R., & Gerba, C. P. (2017). Occurrence of the pathogenic amoeba Naegleria fowleri in groundwater. Hydrogeology Journal, 25(4), 953.

Buss, W., Wurzer, C., Manning, D. A., Rohling, E. J., Borevitz, J., & Mašek, O. (2022). Mineral-enriched biochar delivers enhanced nutrient recovery and carbon dioxide removal. Communications Earth & Environment, 3(1), 67.

Byrne, R. H., Mecking, S., Feely, R. A., & Liu, X. (2010). Direct observations of basin-wide acidification of the North Pacific Ocean. Geophysical Research Letters, 37(2).

Caminade, C., Kovats, S., Rocklov, J., Tompkins, A. M., Morse, A. P., Colón-González, F. J., ... & Lloyd, S. J. (2014). Impact of climate change on global malaria distribution. Proceedings of the National Academy of Sciences, 111(9), 3286-3291.

Caminade, C., Turner, J., Metelmann, S., Hesson, J. C., Blagrove, M. S., Solomon, T., ... & Baylis, M. (2017). Global risk model for vector-borne transmission of Zika virus reveals the role of El Niño 2015. Proceedings of the national academy of sciences, 114(1), 119-124.

Cann, K. F., Thomas, D. R., Salmon, R. L., Wyn-Jones, A. P., & Kay, D. (2013). Extreme water-related weather events and waterborne disease. Epidemiology & Infection, 141(4), 671-686.

Curriero FC, Heiner KS, Samet JM, Zeger SL, Strug L, Patz JA. (2002). Temperature and mortality in 11 cities of the eastern United States. Am J Epidemiol.; 155:80–87. [PubMed] [Google Scholar]

Cecchi L, D'Amato G, Ayres JG, Galan C, Forastiere F, Forsberg B, Gerritsen J, Nunes C, Behrendt H, Akdis C, Dahl R, Annesi-Maesano I. (2010). Projections of the effects of climate change on allergic asthma: The contribution of aerobiology. Allergy.; 65:1073–1081.

Centers for Disease Control and Prevention. (2013). Parasites-Onchocerciasis (also known as river blindness), epidemiology & risk factors. CDC Home Page.

Centers for Disease Control and Prevention. (2020). Parasites—onchocerciasis (also known as river blindness). Epidemiology and risk factors. Available online: https://www. cdc. gov/parasites/onchocerciasis/epi. html (accessed on 19 July 2017).

Change, Intergovernmental Panel On Climate. "Climate change 2007: The physical science basis: The physical science basis.

Charlier, J., Ghebretinsae, A. H., Levecke, B., Ducheyne, E., Claerebout, E., & Vercruysse, J. (2016). Climate-driven longitudinal trends in pasture-borne helminth infections of dairy cattle. International Journal for Parasitology, 46(13-14), 881-888.

Chong, K. L., Ng, C. S., Hori, N., Yang, R., Verzicco, R., & Lohse, D. (2021). Extended lifetime of respiratory droplets in a turbulent vapor puff and its implications on airborne disease transmission. Physical review letters, 126(3), 034502.

Claxton, A., Jacobson, K. C., Bhuthimethee, M., Teel, D., & Bottom, D. (2013). Parasites in subyearling Chinook salmon (Oncorhynchus tshawytscha) suggest increased habitat use in wetlands compared to sandy beach habitats in the Columbia River estuary. Hydrobiologia, 717, 27-39.

Conner MS, Davis JA, Leatherbarrow J, Greenfield BK, Gunther A, Hardin D, Mumley T, Oram JJ, Werne C. The slow recovery of San Francisco Bay from the legacy of organochlorine pesticides. Environ Res. 2007;105:87–100.

Corry, O., & Kornbech, N. (2021). Geoengineering: a new arena of international politics. International Relations in the Anthropocene: New Agendas, New Agencies and New Approaches, 95-112.

Cowan-Ellsberry C, McLachlan M, Arnot J, MacLeod M, McKone TE, Wania F.

Modeling exposure to persistent chemicals in hazard and risk assessment. Integr Environ Assess Manag. 2009;5:662–679.

D'Amato G, Liccardi G, D'Amato M, Holgate S. (2005). Environmental risk factors and allergic bronchial asthma. Clin Exp Allergy. 2005; 35:1113–1124.

Danis, K., Baka, A., Lenglet, A., Van Bortel, W., Terzaki, I., Tseroni, M., ... & Kremastinou, J. (2011). Autochthonous Plasmodium vivax malaria in Greece, 2011. Eurosurveillance, 16(42), 19993.

Davin, E. L., & de Noblet-Ducoudré, N. (2010). Climatic impact of global-scale deforestation: Radiative versus nonradiative processes. Journal of Climate, 23(1), 97-112.

Dereure, J., Vanwambeke, S. O., Malé, P., Martinez, S., Pratlong, F., Balard, Y., & Dedet, J. P. (2009). The potential effects of global warming on changes in canine leishmaniasis in a focus outside the classical area of the disease in southern France. Vector-Borne and Zoonotic Diseases, 9(6), 687-694.

Dhimal, M., Ahrens, B., & Kuch, U. (2015). Climate change and spatiotemporal distributions of vector-borne diseases in Nepal–a systematic synthesis of literature. PloS one, 10(6), e0129869.

Dhimal, M., Gautam, I., Joshi, H. D., O'Hara, R. B., Ahrens, B., & Kuch, U. (2015). Risk factors for the presence of chikungunya and dengue vectors (Aedes aegypti and Aedes albopictus), their altitudinal distribution and climatic determinants of their abundance in central Nepal. PLoS Neglected Tropical Diseases, 9(3), e0003545.

Doherty TJ, Clayton S. The psychological impacts of global climate change. Am Psychol. 2011;66:265–276.

Dos Santos, D. L., Chaúque, B. J. M., Virginio, V. G., Cossa, V. C., Pettan-Brewer, C., Schrekker, H. S., & Rott, M. B. (2022). Occurrence of Naegleria fowleri and their implication for health-a look under the One Health approaches. International Journal of Hygiene and Environmental Health, 246, 114053.

ECDC (2013): Phlebotomine sandflies: distribution maps Stockholm: European Centre for Disease Prevention and Control

Ebi KL, McGregor G. Climate change, tropospheric ozone and particulate matter, and health impacts

Eliason, E. J., Clark, T. D., Hague, M. J., Hanson, L. M., Gallagher, Z. S., Jeffries, K. M., ... & Farrell, A. P. (2011). Differences in thermal tolerance among sockeye salmon populations. Science, 332(6025), 109-112.

Elsaftawy, E., Wassef, R., & Amin, N. (2021). Can endemic parasitic diseases and/or vectors play a role in the COVID-19 pandemic?. Parasitologists United Journal, 14(1), 7-14.

El-Sayed, A., & Kamel, M. (2020). Climatic changes and their role in emergence and re-emergence of diseases. Environmental Science and Pollution Research, 27, 22336-22352..

Evans, K. L., Newton, J., Gaston, K. J., Sharp, S. P., McGowan, A., & Hatchwell, B. J. (2012). Colonisation of urban environments is associated with reduced migratory behaviour, facilitating divergence from ancestral populations. Oikos, 121(4), 634-640.

Fawell J, Nieuwenhuijsen MJ. Contaminants in drinking water. Br Med Bull. 2003;68:199–208.

Földvári, G., Široký, P., Szekeres, S., Majoros, G., & Sprong, H. (2016). Dermacentor reticulatus: a vector on the rise. Parasites & vectors, 9(1), 1-29.

Gage, K. L., Burkot, T. R., Eisen, R. J., & Hayes, E. B. (2008). Climate and vectorborne diseases. American journal of preventive medicine, 35(5), 436-450.

Gálvez, R., Descalzo, M. A., Guerrero, I., Miró, G., & Molina, R. (2011). Mapping the current distribution and predicted spread of the leishmaniosis sand fly vector in the Madrid region (Spain) based on environmental variables and expected climate change. Vector-borne and zoonotic diseases, 11(7), 799-806.

Gassner, F., & van Overbeek, L. S. (2007). 12. Lyme disease in Europe: facts and no fiction. Emerging pests and vector-borne diseases in Europe, 1, 207.

Gaze WH, Zhang L, Abdouslam NA, Hawkey PM, Calvo-Bado L, Royle J, Brown H, Davis S, Kay P, Boxall ABA,

Wellington EMH (2011). Impacts of anthropogenic activity on the ecology of class 1 integrons and integron-associated genes in the environment. Int Soc Microb Ecol J. 2011; 12:1253–1261.

Goll, D. S., Ciais, P., Amann, T., Buermann, W., Chang, J., Eker, S., Hartmann, J., Janssens, I., Li, W., & Obersteiner, M. (2021). Potential CO2 removal from enhanced weathering by ecosystem responses to powdered rock. Nature Geoscience, 14(8), 545-549.

Gordon CJ. (2003). Role of environmental stress in the physiological response to chemical toxicants. Environ Res. 2003; 92:1–7.

Gouin T, Wania F. (2007). Time trends of Arctic contamination in relation to emission history and chemical persistence and partitioning properties. Environ Sci Technol. 2007; 41:5986–5992.

Greenblatt, C. L., Davis, A., Clement, B. G., Kitts, C. L., Cox, T., & Cano, R. J. (1999). Diversity of microorganisms isolated from amber. Microbial ecology, 38, 58-68.

Gunda, R., Chimbari, M. J., Shamu, S., Sartorius, B., & Mukaratirwa, S. (2017). Malaria incidence trends and their association with climatic variables in rural Gwanda, Zimbabwe, 2005–2015. Malaria Journal, 16(1), 1-13.

Gür, T. M. (2022). Carbon dioxide emissions, capture, storage and utilization: Review of materials, processes and technologies. Progress in Energy and Combustion Science, 89, 100965.

Haines, A., & Patz, J. A. (2004). Health effects of climate change. Jama, 291(1), 99-103.

Hakalahti, T., Karvonen, A., & Valtonen, E. T. (2006). Climate warming and disease risks in temperate regions–Argulus coregoni and Diplostomum spathaceum as case studies. Journal of Helminthology, 80(2), 93-98.

Henson, S. A., Cael, B. B., Allen, S. R., & Dutkiewicz, S. (2021). Future phytoplankton diversity in a changing climate. Nature communications, 12(1), 5372.

Herman, E. K., Greninger, A., van der Giezen, M., Ginger, M. L., Ramirez-Macias, I., Miller, H. C., ... & Dacks, J. B. (2021). Genomics and transcriptomics yields a system-level view of the biology of the pathogen Naegleria fowleri. BMC biology, 19, 1-18.

Hofhuis, A., Harms, M., van den Wijngaard, C., Sprong, H., & van Pelt, W. (2015). Continuing increase of tick bites and Lyme disease between 1994 and 2009. Ticks and tick-borne diseases, 6(1), 69-74.

Hubálek, Z. (2021). Pathogenic microorganisms associated with gulls and terns (Laridae). Journal of Vertebrate Biology, 70(3), 21009-1.

Indhumathi, K., & Kumar, K. S. (2021). A review on prediction of seasonal diseases based on climate change using big data. Materials Today: Proceedings, 37, 2648-2652.

Intarapuk, A., & Bhumiratana, A. (2021). Investigation of Armigeres subalbatus, a vector of zoonotic Brugia pahangi filariasis in plantation areas in Suratthani, Southern Thailand. One Health, 13, 100261.

International Programme on Chemical Safety (IPCS) Geneva, Switzerland: Joint publication of the Food and Agriculture Organization and the World Health Organization; 2009. Principles and methods for the risk assessment of chemicals in food. Environmental Health Criteria 240.

Ivanescu, L., Bodale, I., Florescu, S. A., Roman, C., Acatrinei, D., & Miron, L. (2016). Climate change is increasing the risk of the reemergence of malaria in Romania. BioMed Research International, 2016.

Keatinge WR, Donaldson GC, Cordioli E, Martinelli M, Kunst AE, Mackenbach JP, Nayha S, Vuori I. (2000). Heat related mortality in warm and cold regions of Europe: Observational study. BMJ.; 321:670–673.

Keith, D. W. (2000). Geoengineering the climate: History and prospect. Annual review of energy and the environment, 25(1), 245-284.

Kenyon, F., Sargison, N. D., Skuce, P. J., & Jackson, F. (2009). Sheep helminth parasitic disease in south eastern Scotland arising as a possible consequence of climate change. Veterinary parasitology, 163(4), 293-297.

Kolarova, L. (2007). Schistosomes causing cercarial dermatitis: a mini-review of current trends in systematics and of host specificity and pathogenicity. Folia Parasitologica, 54(2), 81.

Krewski D, Burnett RT, Goldberg M, Hoover K, Siemiatycki J, Abrahamowicz M, White WH. (2005). Reanalysis of the Harvard Six Cities Study, Part II: Sensitivity analysis. Inhal Toxicol. 2005; 17:343–353.

Kristensen, N. P., Johansson, J., Ripa, J., & Jonzén, N. (2015). Phenology of two interdependent traits in migratory birds in response to climate change. Proceedings of the Royal Society B: Biological Sciences, 282(1807), 20150288.

Kuchta, R., Oros, M., Ferguson, J., & Scholz, T. (2017). Diphyllobothrium nihonkaiense tapeworm larvae in salmon from North America. Emerging Infectious Diseases, 23(2), 351.

Kulkarni, M. A., Berrang-Ford, L., Buck, P. A., Drebot, M. A., Lindsay, L. R., & Ogden, N. H. (2015). Major emerging vector-borne zoonotic diseases of public health importance in Canada. Emerging microbes & infections, 4(1), 1-7.

Kurittu, P., Khakipoor, B., Brouwer, M. S., & Heikinheimo, A. (2021). Plasmids conferring resistance to extended-spectrum beta-lactamases including a rare IncN+ IncR multireplicon carrying bla CTX-M-1 in Escherichia coli recovered from migrating barnacle geese (Branta leucopsis). Open Research Europe, 1, 46.

Lake IR, Hooper L, Abdelhamid A, Bentham G, Boxall ABA, Draper A, Fairweather-Tait S, Hulme M, Hunter PR, Nichols G, Waldron KW. (2012). Climate change and food security: Health impacts in developed countries. Environ Health Perspect. 2012; 120:1520–1526.

Linderholm L, Jakobsson K, Lundh T, Zamir R, Shoeb M, Nahar N, Bergman Å. (2011). Environmental exposure to POPs and heavy metals in urban children from Dhaka, Bangladesh. J Environ Monit. 2011; 13:2728–2734.

Lu, P., Zhou, Y., Yu, Y., Cao, J., Zhang, H., Gong, H., ... & Zhou, J. (2016). RNA interference and the vaccine effect of a subolesin homolog from the tick Rhipicephalus haemaphysaloides. Experimental and Applied Acarology, 68, 113-126.

MacLeod, M., Riley, W. J., & Mckone, T. E. (2005). Assessing the influence of climate variability on atmospheric concentrations of polychlorinated biphenyls using a global-scale mass balance model (BETR-Global). Environmental science & technology, 39(17), 6749-6756.

Magan N, Medina A, Aldred D. (2011). Possible climate-change effects on mycotoxin contamination of food crops pre- and postharvest. Plant Pathol. 2011; 60:150–163.

Majoros, G., Fehér, Z., Deli, T., & Földvári, G. (2008). Establishment of Biomphalaria tenagophila snails in Europe. Emerging infectious diseases, 14(11), 1812.

Marcogliese, D. J. (2008). The impact of climate change on the parasites and infectious diseases of aquatic animals. Rev Sci Tech, 27(2), 467-484.

Martin, B. T., Nisbet, R. M., Pike, A., Michel, C. J., & Danner, E. M. (2015). Sport science for salmon and other species: ecological consequences of metabolic power constraints. Ecology letters, 18(6), 535-544.

Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., & Shukla, P. R. (2022). Global Warming of 1.5° C: IPCC Special Report on Impacts of Global Warming of 1.5° C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Cambridge University Press.

McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (2001) Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change, 2.

McKone TE, MacLeod M. (2004). Tracking multiple pathways of human exposure to persistent multimedia pollutants: Regional, continental, and global scale models. Annu

Rev Environ Resour. 2004; 28:463–492. [Google Scholar]

Medialdea-Carrera, R., Melillo, T., Gauci, C., Rocco, G., & Borg, M. L. (2018). Is malaria re-emerging in southern Europe? Cryptic Plasmodium falciparum malaria in Malta, October 2018. Eurosurveillance, 23(50), 1800650.

Micallef, M. J. (2016). The Roman fever: observations on the understanding of malaria in the ancient Roman world. Geographica, 5(7).

Miller DB, O'Callaghan JP. Elevated environmental temperature and methamphetamine neurotoxicity. Environ Res.; 92:48–53.

Miller, H. C., Wylie, J., Dejean, G., Kaksonen, A. H., Sutton, D., Braun, K., & Puzon, G. J. (2015). Reduced efficiency of chlorine disinfection of Naegleria fowleri in a drinking water distribution biofilm. Environmental Science & Technology, 49(18), 11125-11131.

Ming, T., Liu, W., & Caillol, S. (2014). Fighting global warming by climate engineering: Is the Earth radiation management and the solar radiation management any option for fighting climate change? Renewable and Sustainable Energy Reviews, 31, 792-834.

Mitra, A. K., & Mawson, A. R. (2017). Neglected tropical diseases: epidemiology and global burden. Tropical medicine and infectious disease, 2(3), 36.

Miraglia, M.,Marvin, H.J., Kleter, G.A., Battilani, P., Brera, C., Coni, E., Cubadda, F., Croci, L., De Santis, B., Dekkers, S., Filippi, L., Hutjes, R.W., Noordam, M.Y., Pisante, M., Piva, G., Prandini, A., Toti, L., van den Born, G.J., Vespermann, A. (2009). Climate change and food safety: An emerging issue with special focus on Europe. Food Chem Toxicol.; 47:1009–1021.

Monge-Maillo, B., & López-Vélez, R. (2012). Migration and malaria in Europe. Mediterranean Journal of Hematology and Infectious Diseases, 4(1).

Moore, S., Shrestha, S., Tomlinson, K. W., & Vuong, H. (2012). Predicting the effect of climate change on African trypanosomiasis: integrating epidemiology with parasite and vector biology. Journal of the Royal Society Interface, 9(70), 817-830.

Mor S, Walsh M, Willem de Smalen A (2018) Climatic influence on anthrax suitability in warming northern latitudes Morgan J, Dejong R, Snyder S, Mkoji G, Loker E (2001) Schistosoma mansoni and Biomphalaria: past history and future trends. Parasitology 123:211–228

Moriyama, M., Hugentobler, W. J., & Iwasaki, A. (2020). Seasonality of respiratory viral infections. Annual review of virology, 7, 83-101.

Nakazawa, Y., Williams, R., Peterson, A. T., Mead, P., Staples, E., & Gage, K. L. (2007). Climate change effects on plague and tularemia in the United States. Vector-Borne and Zoonotic Diseases, 7(4), 529-540.

Navarro, J., Grémillet, D., Afán, I., Miranda, F., Bouten, W., Forero, M. G., & Figuerola, J. (2019). Pathogen transmission risk by opportunistic gulls moving across human landscapes. Scientific reports, 9(1), 10659.

Neghina, R., Neghina, A. M., Marincu, I., & Iacobiciu, I. (2011). International travel increases and malaria importation in Romania, 2008–2009. Vector-Borne and Zoonotic Diseases, 11(9), 1285-1288.

Nellemann, C., Corcoran, E., Duarte, C. M., De Young, C., Fonseca, L. E., & Grimsdith, G. (2010). Blue carbon: the role of healthy oceans in binding carbon.

Nicolescu, G., Purcarea-Ciulacu, V., Vladimirescu, A., Dumitrescu, G., Saizu, D., Savin, E., ... & Mihai, F. (2016). Could malaria re-emerge in Romania? International Journal of Infectious Diseases, 45, 187-188.

O'Dwyer, J., Morris Downes, M., & Adley, C. C. (2016). The impact of meteorology on the occurrence of waterborne outbreaks of vero cytotoxin-producing Escherichia coli (VTEC): a logistic regression approach. Journal of Water and Health, 14(1), 39-46.

O'Reilly, C. M., Sharma, S., Gray, D. K., Hampton, S. E., Read, J. S., Rowley, R. J., ... & Zhang, G. (2015). Rapid and highly variable warming of lake surface waters around the globe. Geophysical

Research Letters, 42(24), 10-773. Physiology, 2(3), 2151-2202.

Paterson RR, Lima N. (2010). Toxicology of mycotoxins. EXS. 2010; 100:31–63.

Porretta, D., Mastrantonio, V., Amendolia, S., Gaiarsa, S., Epis, S., Genchi, C., ... & Urbanelli, S. (2013). Effects of global changes on the climatic niche of the tick Ixodes ricinus inferred by species distribution modelling. Parasites & Vectors, 6, 1-8.

Portier, C. J., Tart, K. T., Carter, S. R., Dilworth, C. H., Grambsch, A. E., Gohlke, J., ... & Whung, P. Y. (2013). A human health perspective on climate change: a report outlining the research needs on the human health effects of climate change. Journal of Current Issues in Globalization, 6(4), 621.

Redshaw, C. H., Stahl-Timmins, W. M., Fleming, L. E., Davidson, I., & Depledge, M. H. (2013). Potential changes in disease patterns and pharmaceutical use in response to climate change. Journal of Toxicology and Environmental Health, Part B, 16(5), 285-320.

Rezza, G., Nicoletti, L., Angelini, R., Romi, R., Finarelli, A. C., Panning, M., ... & Cassone, A. (2007). Infection with chikungunya virus in Italy: an outbreak in a temperate region. The Lancet, 370(9602), 1840-1846.

Sadeghmoghadam, L., Daneshfar, M., Sharifi, F., & Alizad, V. (2020). How the first cases of COVID-19 in 10 countries become infected? a case series. Respiratory Medicine Case Reports, 101219.

Sanyaolu, A., Okorie, C., Badaru, O., Wynveen, E., White, S., Wallace, W., ... & Perry, C. (2016). Chikungunya epidemiology: a global perspective. SM J Public Health Epidemiol, 2(2), 1028.

Satterfield, D. A., Maerz, J. C., & Altizer, S. (2015). Loss of migratory behaviour increases infection risk for a butterfly host. Proceedings of the Royal Society B: Biological Sciences, 282(1801), 20141734.

Scheringer, M. (1997). Characterization of the environmental distribution behavior of organic chemicals by means of persistence and spatial range. Environmental science & technology, 31(10), 2891-2897.

Semenza, J. C., & Ebi, K. L. (2019). Climate change impact on migration, travel, travel destinations and the tourism industry. Journal of Travel Medicine, 26(5), taz026.

Shah, A. H., Abdelzaher, A. M., Phillips, M., Hernandez, R., Solo-Gabriele, H. M., Kish, J., ... & Fleming, L. E. (2011). Indicator microbes correlate with pathogenic bacteria, yeasts and helminthes in sand at a subtropical recreational beach site. Journal of applied microbiology, 110(6), 1571-1583.

Shankardass, K., McConnell, R. S., Milam, J., Berhane, K., Tatalovich, Z., Wilson, J. P., & Jerrett, M. (2007). The association between contextual socioeconomic factors and prevalent asthma in a cohort of Southern California school children. Social science & medicine, 65(8), 1792-1806.

Shikanai-Yasuda, M. A., & Carvalho, N. B. (2012). Oral transmission of Chagas disease. Clinical Infectious Diseases, 54(6), 845-852.

Smith, K. R., Chafe, Z., Woodward, A., Campbell-Lendrum, D., Chadee, D. D., Honda, Y., ... & Haines, A. (2015). Human health: impacts, adaptation, and co-benefits. In Climate Change 2014 Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects (pp. 709-754).

Sousa, C. A., Clairouin, M., Seixas, G., Viveiros, B., Novo, M. T., Silva, A. C., ... & Economopoulou, A. (2012). Ongoing outbreak of dengue type 1 in the Autonomous Region of Madeira, Portugal: preliminary report. Eurosurveillance, 17(49), 20333.

Stahl, L. M., & Olson, J. B. (2021). Environmental abiotic and biotic factors affecting the distribution and abundance of Naegleria fowleri. FEMS Microbiology Ecology, 97(1), fiaa238.

Talapko, J., Škrlec, I., Alebić, T., Jukić, M., & Včev, A. (2019). Malaria: the past and the present. Microorganisms, 7(6), 179.

Tattersall, G. J., Sinclair, B. J., Withers, P. C., Fields, P. A., Seebacher, F., Cooper, C. E., & Maloney, S. K. (2012). Coping with thermal challenges: physiological adaptations to environmental temperatures. Comprehensive

Thompson, A. A., Matamale, L., & Kharidza, S. D. (2012). Impact of climate change on children's health in Limpopo Province, South Africa. International Journal of Environmental Research and Public Health, 9(3), 831-854.

Tirado, M. C., Clarke, R., Jaykus, L. A., McQuatters-Gollop, A., & Frank, J. M. (2010). Climate change and food safety: A review. Food Research International, 43(7), 1745-1765.

Tokarevich, N. K., Tronin, A. A., Blinova, O. V., Buzinov, R. V., Boltenkov, V. P., Yurasova, E. D., & Nurse, J. (2011). The impact of climate change on the expansion of Ixodes persulcatus habitat and the incidence of tick-borne encephalitis in the north of European Russia. Global health action, 4(1), 8448.

Tsao C-C, Campbell JE, Mena-Carrasco M, Spak SN, Chen Y. (2012). Increased estimates of air-pollution emissions from Brazilian sugar-cane ethanol. Nat Clim Change; 2:53–37

Urban, M. C., Bocedi, G., Hendry, A. P., Mihoub, J. B., Pe'er, G., Singer, A., ... & Travis, J. M. (2016). Improving the forecast for biodiversity under climate change. Science, 353(6304), aad8466.

Walsh, M. G., de Smalen, A. W., & Mor, S. M. (2018). Climatic influence on anthrax suitability in warming northern latitudes. Scientific reports, 8(1), 9269.

White, D. H., & Walcott, J. J. (2009). The Role of Seasonal Indices in Monitoring and Assessing Agricultural and Other Droughts: A Review. Crop and Pasture Science, 60, 599-616.https://doi.org/10.1071/CP08378

Wiener, M. H. (2014). The interaction of climate change and agency in the collapse of civilizations ca. 2300–2000 BC. Radiocarbon, 56(4), S1-S16.

Williamson, C. E., Madronich, S., Lal, A., Zepp, R. G., Lucas, R. M., Overholt, E. P., ... & Lee-Taylor, J. (2017). Climate change-induced increases in precipitation are reducing the potential for solar ultraviolet radiation to inactivate pathogens in surface waters. Scientific Reports, 7(1), 1-12.

Wongprompitak, P., Kusuwan, N., Khowawisetsut, L., Phuakrod, A., Pipatsatitpong, D., & Wongkamchai, S. (2022). Molecular and Antifilarial IgG4 Detection Using the miniPCR-Duplex Lateral Flow Dipstick and Bm Sxp-ELISA in Myanmar Immigrant Communities. Parasitologia, 2(1), 27-36.

Żbikowska, E., Walczak, M., & Krawiec, A. (2013). Distribution of Legionella pneumophila bacteria and Naegleria and Hartmannella amoebae in thermal saline baths used in balneotherapy. Parasitology research, 112, 77-83.

Zeballos-Gross, D., Rojas-Sereno, Z., Salgado-Caxito, M., Poeta, P., Torres, C., & Benavides, J. A. (2021). The role of gulls as reservoirs of antibiotic resistance in aquatic environments: A scoping review. Frontiers in Microbiology, 12, 703886.

الملخص العربى

تأثير السموم على التغيرات المناخية وطب المسافرين

ايناس الصفطاوي١،٢ أحمد حمدي السيد بدر٣،٤ أماني عبد الفتاح ٥
دينا محمد نجيب عبد المعوض ٦،٧ فاطمة ندا خليفة ٥،٧

١- قسم الطفيليات الطبية، كلية الطب البشري، جامعة القاهرة
٢- قسم الطفيليات الطبية، كلية الطب بالقوات المسلحة، القاهرة، مصر
٣- قسم الأحياء الطبية والمناعة، الأكاديمية الطبية العسكرية، القاهرة، مصر
٤- مركز البحوث الطبية والطب التجديدي، القاهرة، مصر
٥- قسم الطب الشرعي والسموم الاكلينيكية، كلية الطب، جامعة القاهرة
٦- قسم الطب الشرعي والسموم الاكلينيكية، كلية الطب، جامعة الزقازيق
٧- قسم الطب الشرعي والسموم الاكلينيكية، كلية الطب، جامعة بدر القاهرة

المقدمـة: إن تغييـر المنـاخ العـالمي علـى وشـك تغييـر درجـة تعـرض الإنسـان للسـموم واسـتجابة مجموعـات البشـر لهـذه الاتصالات ، مما يعني أن مخاطر الملوثات يمكن أن تتغير في المستقبل، ومن المتوقع أن تزيد دول مجلس التعاون الخليجي من مستوى التعرض للعديد من الملوثات البيئية في أجزاء عديدة من العالم بسبب الانتماءات المباشرة وغيـر المباشـرة علـى تصميمات الاستخدام والنقل ومصير المواد الكيميائية. ستؤثر التغييرات في الأداء البشري أيضًـا علـى كيفيـة اتصـال البشـر بالهواء والماء والغذاء الملوثين، ويمكن أن تؤدي الي الإجهاد النفسي الاجتماعي والتغييرات الغذائية والـتلامس مـع عوامـل الإجهاد، و من المرجح أن تزيد درجات الحرارة من قابلية الإنسـان للإصـابة بـالمواد الكيميائيـة وأن يكـون لهـذه التغييـرات استنتاجات مهمة للممارسات الحالية للتقييم الكيميـائي. قـد لا تنطبـق التقاليـد المسـتخدمة فـي النسـخ المتماثلـة الحاليـة لتقيـيم التعرض ، وقد لا تكون طرق الفحص الحالية قوية بما يكفـي لاكتشـاف التغيـرات المتفرقـة المعاكسـة فـي التعـرض. **هدف الدراسة:** تستكشف مقالة المراجعة الحالية كيف يمكن لدول مجلس التعاون الخليجي أن تلمس السـلالم المختلفـة فـي المسـار من مصدر كيميائي في البيئة إلى التأثيرات على صحة الإنسان وتقييم مقترحات لتقييم المخاطر الحاليـة وممارسـات الإدارة. **الطرق المسـتخدمة:** تـم تجميـع المقـالات باسـتخدام كلمـات رئيسـية ملائمـة مـن خـلال الباحـث العلمـي مـن Google ، و PubMed، وبنك المعرفة المصري (EKB) ، ومكتبة وايلي على الإنترنت ، وشبكة العلوم. معايير التضـمين: الدراسـات التي تمت مراجعتها من قِبل النظراء ، والمراجعات التحليلية الوصفية والسردية ، وتقارير منظمة الصحة العالمية المنشورة في الحقبة بين عامي 1995 و 2022. معـايير الاسـتبعاد: مقـالات عبـر الإنترنـت غيـر مرتبطـة بقاعـدة بيانـات ملتزمـة أو مقالات ذات وصول مغلق. **النتائج:** هناك حاجة لمزيد من البحوث والدراسات للوقاية في دول مجلس التعاون الخليجي.