

## **INTRODUCTION: WHY FOCUS PAPER ON INFECTIOUS DISEASES AND PFAS “FOREVER CHEMICALS”?**

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The main objective will be to initially get reader interest considering this issue that would not just affect a limited population near a localized Superfund site for example, but be very relevant to any of the readers that likely has been affected by these issues to some degree. The potential for rare and novel diseases to appear in the United States has been already observed and the possibility for future pandemics should not be presented as "scare tactics" but as a priority issue for elected officials, scientists, and concerned citizens to focus and prioritize for this and new generations.

The detection of Per- and polyfluoroalkyl substances (PFAS) in humans and other environmental receptors has been a significant issue with still research on the various compounds in this family. They were common compounds in everyday use and now detected in most human and other animals tested. The risk based levels have been established for the U.S. Environmental Protection Agency (USEPA) and various states although the research and debates on still very low acceptable levels in environmental media continues.

Separately both of these issues are significant for the current and future generations. However, this paper attempts to summarize various research articles on each issue and also tie in the relationship of both.

The objectives of this paper:

1. Provide educational and interesting introduction to stimulate the reader to continue to research additional information on PFAS compounds, changes in infectious disease patterns, and the relation of the two significant issues.
2. Provide evidence mainly from peer reviewed research articles, discussions with various experts, and government information on the ecology, environmental, and genetic factors for the changes in infectious diseases and PFAS compounds
3. Provide summary that would point out the serious aspects of PFAS in human and other receptors and the resulting decrease in resistance to diseases. The summary will not be presented in a total “gloom and doom” fashion but focus on potential solutions not limited to continued research and preparation for adequate responses.
4. The ecological, environmental, and genetic factors would also provide talking points to elected officials and interested concerned citizens on the "Forever Chemicals" and the documented health effects of low and high exposures. This also has direct tie in to issues such as

"climate change" where various government agencies and significant peer reviewed research articles on changes in infectious disease patterns in the United States and other countries.

This writer had originally researched some of this information when assisting the environmental group Climate Change Lobby (CCL) with "talking points" for elected officials regarding climate change and various potential effects that would be significant to this and future generations of Pennsylvania residents. The search on various topics utilized peer reviewed science articles and government agency information considered reliable and avoided media and specific organization information that might be considered biases. During the early preparation it was found that the amount of information required separating the bullet talking points into specific sections. During this task the climate change and changes in infectious diseases, and climate change and food security was completed and provided to CCL although these are still a work in progress.

While the initial infectious disease bullet item research focused on climate change the information noted other significant factors that interacted not limited to population increase, land use competition, loss of habitat, and potential loss of resistance to disease due to evolution of bacteria and virus types, and potential decrease in health benefits and research funding to humans, animals, and plants.

## **WHY PER-AND POLYFLUOROALKYL (PFAS) COMPOUNDS?**

Anyone that has seen the recent "Dark Waters" (2019) movie that dramatizes the decades of legal actions against the current DuPont de Nemours Corporation (Dupont) might understand the logic for this selection. The majority of the legal action focused on the Teflon production at the Parkersburg, West Virginia facility. While the movie reflected reality (S. L. Caspar, personal communications 2020<sup>1</sup>) of the initial and subsequent U.S. Environmental Agency (USEPA) investigations, the evidence utilized peer reviewed research and federal and state agency information to select these compounds.

The Agency for Toxic Substances and Disease Registry (ATSDR, 2018) Toxicological Profile<sup>ii</sup> would be one of the sources on the potential health cancer and non-cancer health effects on exposure to PFAS compounds. Stein, C. R et al., (2014)<sup>iii</sup> also note the teratogenic potential for birth defects with one of the most common PFAS compounds noted as Perfluorooctanoate (PFOA). One of the residents whose mother was exposed to these compounds on the Teflon production line showed a son that had highly visible facial deformities was one of the extras in the referenced movie. The health effects of PFAS compounds have been documented and appear to be supported even more than many of the organic and inorganic contaminants more common at various hazardous waste cleanup sites and emergency response spills. However, the active research still continues not just on various sites in Pennsylvania and other states, but on potential exposure at municipal/residual waste landfill and other areas.

The U.S. Environmental Protection Agency (USEPA) states that two of the most common PFAS compounds are perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). The

USEPA (2017)<sup>iv</sup> Technical Fact Sheet notes that these compounds are not just limited to exposures from production or disposal areas for these wastes as referenced in the Parkersburg, West Virginia locations, but are common current and historical exposures to various products common to normal life. While DuPont might be one of the main "villains" in the media, note that 3M Corporation that produced Scotchgard for stain resistant fabrics, and even local facilities such as the local Valmont TCE Superfund site (West Hazleton, Pennsylvania) utilized these compounds (USEPA, 2020) during their production. The USEPA (2016)<sup>vi</sup> latest five-year report notes that PFAS compounds have been detected in multiple groundwater monitoring wells on-site. This normal procedure evaluates the defined remedy and the progress and additional actions that may be required. The August 2016 report notes that the groundwater concentrations (some pending at time of this report) was above the toxicological screening level of 0.4 ppb (400 ppt). This risk-based toxicological screening level was based on conventional Superfund default exposure factors with a Hazard Index (HI) of 1.0. The continued evaluation of the remedy and the detections of PFAS would be on-going. An important note would be that during the latter part of 2019 the Interim Standard<sup>vii</sup> for PFAS compounds that may warrant further investigation in the event PFOA or PFOS would be present was 40 parts per trillion as compared with the above Valmont TCE level several years earlier. This example should note that these compounds can be found in local areas of specific industries and that the risk levels for action are still evolving.

The objective of this section was to show that unlike many common organic or inorganic contaminants, these PFAS compounds are documented in human biological samples, and exposure in the past and during current times has also been common with respect to products. Oddly enough, a local roofing company in Dunmore, Pennsylvania had a television commercial on September 24, 2020 that touted that their roofing shingles were treated with Scotchgard! The positive point was while the name was the same, the 3M Company Frequently Asked Questions<sup>viii</sup> states that the new Scotchgard no longer contains PFAS and copper the active ingredient for algae protection. Another important consideration would be that PFAS compounds have been documented to have significant cancer and non-cancer effects that should not be overlooked. This paper focuses on the hypothetical and documented effects being studied on the decrease of normal resistance to infectious diseases.

## **WHY INFECTIOUS DISEASES?**

The COVID19 pandemic would be the obvious infamous problem with current infectious diseases. The Severe Acute Respiratory Syndrome (SARS) Corona Virus (CoV2) virus strain has been considered novel during the initial stages of the pandemic. However, this particular virus would be a member of a family of coronaviruses that has not been a stranger to humans and animals historically. The highly infectious and deadly symptoms have been documented by the Centers for Disease Control (CDC) over decades with various outbreaks in different countries.

The Rahalkar, M.C. & Bahulikar, R.A (2020)<sup>ix</sup> provisionally accepted research paper provides information on Wuhan outbreak where Mojang miners deaths during 2012 suspected to be from a coronavirus. This occurred in a copper mine located in western China and samples are believed to be a close relative of the current SARS CoV2 virus. The CDC (2004)<sup>x</sup> had also been

instrumental in banning the importation of civet cats (famous in the biological production of Kopi Luwak coffee) due to an outbreak of coronavirus that originated at a restaurant in Wuhan. This particular outbreak spread to two dozen countries during 2003 with 8,098 positive COVID confirmed cases, and 774 deaths. There was estimated 192 positive cases in the United States from this outbreak. Fortunately, these historical outbreaks of COVID family viruses did not have the similar impact as the current pandemic but the objective would be to point out that coronavirus outbreaks have been recorded and may be a potential in the future.

The Director of National Intelligence (2018)<sup>xi</sup> provided a report on the potential for global threats including the impacts of climate change. The report notes the current extinction rate may be 100 to 1,000 times the normal extinction rate. The health impacts also show the increasing resistance of bacterial, virus, and fungal pathogens to drugs, and expansion of vector borne diseases due to climate change.

Rochlin, I et al. (2013)<sup>xii</sup> note in climate change scenarios that the land areas for *Aedes albopictus* will increase 43 to 49 percent by the end of the century in the Northeastern United States. There will also be significant land area increases in the species population in the next few decades. However, the study concludes that high populations of this mosquito will affect an estimated thirty million people in the Northeastern United States with associated viruses by the end of this century. While this might seem as a surprise to residents of the Northeastern part of the United States the implications of the increase in territory of the *Aedes* mosquito brings the potential of infectious diseases rare to this part of the world. The World Health Organization (2020)<sup>xiii</sup> also notes that the additional areas may be favorable to the *Aedes* mosquito due to climate change. Several species of these mosquitos have been associated with transmission of Zika. These mosquitos have also been associated with transmitting Dengue, Yellow Fever, and Chikungunya viruses. Mosquito vectors have been implicated in large epidemics although little is known on public health implications. The epidemic in Florida during 2016 will be mentioned a bit later in this paper.

Khubchandani, J. et al. (2020)<sup>xiv</sup> note that there are existing and mutating current infectious diseases that we should be prepared for not limited to Ebola which until recently was not really much of a concern in the United States. One of the main determinants on increasing infectious diseases relatively unknown in the United States would be pollution. This also considers increases in greenhouse gases as one of the potential factors in the changing world.

While this might appear to be unsupported speculation to some readers on being a significant potential the Regenaron Corporation Press Release (July 29, 2020)<sup>xv</sup> notes:

*“ Biomedical Advanced Research and Development Authority (BARDA), part of the Office of the Assistant Secretary for Preparedness and Response within the U.S. Department of Health and Human Services (HHS), has entered into an agreement to procure REGN-EB3 as part of the HHS' goal of building national preparedness for public health emergencies.”*

This federal contract would be part of the effort to prepare for known and novel infectious diseases that may follow in the footsteps of the COVID19 pandemic. The drug to be produced

under the six-year contract would be hundreds of millions to this experienced biomedical company

The Federal Emergency Management Agency (2011)<sup>xvi</sup> notes that factors such as increasing temperatures and extremes in storm events will increase disease risk transmitted by food, water, and insect vectors. The predictions that disease patterns will change for the worse due to climate change, an increasing over sixty-five age population, and other factors has also been stated.

There was various other government and peer reviewed research articles on the anticipated increase in diseases and including those considered rare for the United States and potentially novel diseases not just for humans, but for other animal and plant receptors that will likely be a significant issue for this and new generations.

### **WHAT'S THE CONNECTION?**

These PFAS compounds were found in many products that not just high level exposure to industrial workers, but typical products most people would utilize, and were exposed from infant to adult life. This writer has also discussed and recommended specific sampling for these compounds at several northeastern Pennsylvania facilities with Pennsylvania Department of Environmental Protection (Mellow, J.S.(2020)<sup>xvii</sup>) where disposal of residual/municipal wastes and construction/demolition wastes have been utilized or proposed in Northeastern Pennsylvania. Preliminary sampling results from various limited studies including state agencies have shown that PFAS compounds might be realistically detected at these types of common NEPA facilities although the exposure would still be unknown due to lack of data and evaluations. The Interstate Technology Regulatory Council (ITRC) has published the PFAS Working Group Guidance Document (ITRC, 2020)<sup>xviii</sup> that provides updated information on various common products and continues the discussions on future sampling to resolve data gaps.

The arguments to get to the point of the connection are a bit lengthy but felt necessary to provide debatable and clear connections as this would be on-going research and still data gaps. The points note that PFAS compounds are common in many products used by most Americans. However, the final point would be the documented exposure noted by health agencies and the Red Cross blood investigations. This point was brought out in this writer's arguments to PADEP to justify sampling at several facilities as noted. The argument on the majority of Americans that have had detectable PFAS in their blood is provided from the referenced correspondence as follows<sup>xix</sup>:

*"Olsen, G. W. et al., (2012) study of recent PFAS compounds in American blood have shown levels have been going down. The study has shown that PFOA and PFOS concentrations have decreased with time at the six major city collection points. However, this study also shows that PFAS compounds are still in the blood of an estimated 99 percent of Americans. The important factor for this argument would be that the conclusions noted that the decrease in blood might not be observed for areas with specific industrial types of facilities not limited to specially named landfills."*

The shocking revelation should be that almost everyone living in the United States likely has PFAS compounds in detectable concentrations in their blood. While Red Cross Distribution Centers have seen a decrease in various PFAS compounds they are still there in possibly high concentrations. The point to be taken should be almost everyone has been exposed but the last argument provides the significance of the connection on PFAS and infectious disease resistance.

The ATSDR has been a major partner with the state and federal environmental agencies and state health agency on the assessment of the assessment and remediation of PFAS cleanup sites and sampling at potential source areas. Recently, the ATSDR has documented that the potential question that PFAS exposure may have affected resistance to the COVID19 pandemic brings up the genetics, environment, and ecological ("GEE") factors that will be discussed in this project. While investigations and any conclusions based on empirical data this appears to be a topic significant to most of Americans. The ATSDR (2020)<sup>xx</sup> concern on the question has been provided to provide clear point on the position of a question still to answer.

***"Statement on Potential Intersection between PFAS Exposure and COVID-19:"***

*"CDC/ATSDR understands that many of the communities we are engaged with are concerned about how PFAS exposure may affect their risk of COVID-19 infection. We agree that this is an important question."*

*"CDC/ATSDR recognizes that exposure to high levels of PFAS may impact the immune system. There is evidence from human and animal studies that PFAS exposure may reduce antibody responses to vaccines (Grandjean et al., 2017, Looker et al., 2014), and may reduce infectious disease resistance (NTP, 2016). Because COVID-19 is a new public health concern, there is still much we don't know. More research is needed to understand how PFAS exposure may affect illness from COVID-19."*

The preceding sections objective was to make a convincing argument that the contaminants and their link to potential infectious disease should be significant. While the science still requires more research and potential refinements in evaluations, the references utilized by ATSDR and additional research articles will attempt to link these "Genetic, Environmental, and Ecological (GEE)" factors.

## GENETICS:

Mr. Bucky Bailey (age 35 during time of filming) was one of the extras in the “Dark Waters” (2019)<sup>xxi</sup> movie that dramatized the legal action against Dupont with regard to PFAS compounds. His family was also one of main parts of the “The Devil We Know” (2018)<sup>xxii</sup> documentary movie. This person was born with one nostril and a deformed face and his mother worked on the Teflon production line at the Parkersburg facility in West Virginia. Ms. Bailey was exposed to PFAS compounds during her pregnancy in the 1980s and alleged blood samples did confirm these compounds in her blood. While this was one of the more dramatic examples of using alleged (due to this paper not having access to evaluated data) victims of exposure during the filming, there were others that had been exposed and tested that were extras in this movie. While significant medical evaluations may exist on these cases, this paper does not have access to this empirical evidence that may exist on the link of PFAS and these health effects. However, this anecdotal information would suggest that this evidence does exist based on the known health effects noted by ATSDR and other science sources and the successful lawsuits against Dupont.

Bucky Bailey’s mother worked on the Parkersburg facility Teflon line where high levels of PFAS chemicals were routinely exposed to line workers. However, this paper would focus on what the general public might be exposed to in lower levels and the significance to resistance to infectious diseases. The U.S. Environmental Agency (USEPA) has a PFAS Working Group at their Washington D.C. Headquarters. The USEPA typically draws expertise from government and private entities during research on risk based levels in environmental media. Those that are familiar with drinking water risk based levels might know that many organic carcinogens and suspected carcinogens typically have acceptable levels in the low part per billion concentrations. The ATSDR (2020)<sup>xxiii</sup> has also developed “minimal risk levels” for several specific PFAS compounds that are common in the environment. These MRL’s are 52 parts per trillion (adult) and 14 parts per trillion (child) for perfluorooctane sulfonic acid (PFOS) and 78 parts per trillion (adult) and 21 very low concentrations (parts per trillion) have been associated with health effects based on best available information.

Wen, Yi, et al. (2020)<sup>xxiv</sup> studied the effects of PFOA and the recent industrial replacement GenX. The conclusions of the research provided qualifications that additional studies should be done to further define the epigenetic effects of both compounds. However, the study did show that metabolism rates, gene expression, and other factors were altered by both chemicals. PFOA appears to be more prominent than GenX although both had effects on the cellular properties. This study appears to be significant in the continued research on how these chemicals may influence liver cancer and other negative effects.

The National Toxicology Program (2016)<sup>xxv</sup> monograph shows that both PFOS and PFOA suppress the immunotoxicity although the mechanism has not been quite understood at that point in time. While the conclusion notes that there are gaps in the understanding there appears to be potential that these compounds act in multiple ways to suppress the immunotoxicity and the

natural killer (NK) cells that suppress disease and tumors.

Gonzalez-Rodriguez, A.P et al. (2019)<sup>xxvi</sup> note that the NK cells are activated or inhibited (by receptors on various cells. These cells recognize the surface proteins located on all healthy cells. If the normal healthy recognition of these receptors has not been found by the NK cell, then the activation of toxic cytokines are injected into the receptors of virus or cancer cells. The apparent policing system then would be weakened by PFOS and PFOA (possibly other PFAS compounds?) in the body.

The above sections explain the importance of the NK cells and the link that PFAS compounds can suppress the action of these cells. The genetics relation would still be a bit vague on these killer cells. Temkin, A. M. et al. (2020)<sup>xxvii</sup> provide more recent information on the literature regarding the classification of PFAS (mainly PFOS and PFOA) as carcinogens. The research noted that generally PFAS compounds are not genotoxic (directly damaging to the DNA) although secondary damage may be due to oxidative damage. These compounds appear to also be involved in methylation of specific genes. The limited data appears to implicate mainly PFOS and PFOA in this process and appears to be transferred from an exposed mother to offspring cord blood and associated with effects on genes on embryonic growth and development. The PFAS compounds have also been associated with oxidative stress. This is an imbalance of reactive oxygen species (ROS) and the damage not limited to DNA and proteins. This research goes on to list and describe other carcinogenic and non-carcinogenic effects in children and adults. The objective of the study appears to successfully defend that the key characteristics of listing PFAS compounds as carcinogens has been met in at least five categories. The objective of this paper would be to demonstrate that research acknowledges the limited data but recent evaluations indicate that these compounds appear to be associated with genetic changes.

Waterfield, G. et al. (2020)<sup>xxviii</sup> provides a recent study in Minnesota where portion of the population of St. Paul area was exposed to PFAS in drinking water in the study from 2002 to 2011. The installation of a filtration system during 2006 provided a time-line when PFAS were at non-detectable levels in drinking water. The study looked at over 48,000 live birth records from the Minnesota Department of Health and considered socioeconomic factors and birth weight and gestational age from the various zip codes. The study did find statistically significant changes (95 percent confidence level) in birth weights in births from mothers exposed to PFAS (specifically PFOS and PFOA) in drinking water compared to those after the installation of the filter system and in control areas. The authors do state the changes are modest but does indicate that continued research and possibly even lower drinking water levels than the recommended 70 parts per trillion should be considered. Possibly these studies suggest that the heritability (genetics) as well as the environmental concerns based on current research are significant with PFAS compounds and the shorter chain replacements like GenX.

## **ENVIRONMENT**

The previously cited study by Olsen, G.W. et al., (2012) study of recent PFAS compounds in American blood have shown levels have been going down. The study has shown that PFOA and PFOS concentrations have decreased with time at the six major city collection points. However, this study also shows that PFAS compounds are still in the blood of an estimated 99 percent of

Americans. The important factor for this argument would be that the conclusions noted that the decrease in blood might **not** be observed for areas with specific industrial types of facilities not limited to specially named landfills. The study shows graphical trends in six Red Cross Distribution Centers (none in Pennsylvania) show decrease in PFOS and PFOA in nanograms per milliliter samples from 2000 to 2015. These samples were analyzed at 3M laboratories and compared to earlier samples by Centers for Disease Control and Prevention (CDC) National Health and Nutrition Examination Survey (NHANES) program. The data also provided information on eleven other PFAS compounds besides the most common PFOS and PFOA.

Kotlarz, N. et al. (2020) provides research article on blood levels near a Wilmington, North Carolina manufacturing facility. This facility discharged PFAS and other compounds into the Cape Fear River that serves as a source of drinking water for residential and commercial users. During November 2018<sup>xxix</sup> and May 2019 blood samples were collected from 344 participants ranging from six to eighty-six years of age. Repeat blood samples were collected from forty-four participants during 2019. Household, personal, and drinking water sources was part of the additional data collected from the participants. Ten fluoroethers and ten PFAS compounds (including the discussed PFOA and PFOS compounds) were analyzed. The baseline comparison was done in North Carolina areas remote from the facility. This was from twenty achieved samples from an unrelated study .

The study provided statistical evaluation of the fluoroethers and PFAS compounds. However, for this report the PFOS and PFOA results are provided for reference but were not the only detected compounds. The median concentration for PFOS and PFOA for adults was respectively 9.4 and 4.8 nanograms per milliliter, and 5.1 and 3.0 nanograms per milliliter for children. Box and Whisker Plots were provided for these compounds comparing national NHANES data with the Wilmington data. These PFOA data appear to show a significant change from the national data, while the PFOS was higher but the error range overlapped by a small degree. The main conclusion was that the discharges from the facility provided elevated PFAS and fluoroethers into the surface water that was a pathway for human receptors. The ecological receptors were not discussed in this detailed research paper. However, note the example of these contaminants entering the environment and detected in human receptors blood thru the surface water pathway. This may also be an example where water treatment facilities normal surface water treatment does not have an impact on PFAS compounds.

While the human receptors should be significant data on the seriousness of these compounds in the environment, Purdue University News Service (2020)<sup>xxx</sup> notes that PFAS compounds have also been detected in whales and polar bears. This indicates that even remote ocean and polar receptors have not escaped the exposure to these compounds. The Purdue research has also been discussed in the “Genetics” section.

Giesy, J.P. and Kannan, K (2001)<sup>xxxi</sup> study provided the results of biological samples of wildlife for PFOS from fifteen global locations. The results of the analytical data indicated the presence of PFOS in various seal species, eagles, turtles, frogs, salmon, trout, and other species. Some of these samples of liver and plasma was in 100s and 1,000s of nanograms per milliliter.

While shorter chain PFAS replacements have been used in food packaging and possibly other current and common uses, there may also be problems with these compounds even less evaluated at this point in time. Seltnerich, N. (2020)<sup>xxxii</sup> notes that the shorter chain compounds replacing PFOA and PFOS may also be significant with respect to negative health effects and would be common items that could eventually end up in environmental receptors. The example of current fast food and pizzeria packaging notes that the less PFAS was found in individuals in a population that prepared most of the food at home.

As stated in the above section the peer reviewed research has shown that climate change and other factors has predicted spread of rare disease vectors into range of the Northeastern United States within a few decades. The City of Santa Barbara Mosquito and Vector Management Control (2020 retrieved)<sup>xxxiii</sup> has noted that two invasive *Aedes albopictus* (Asian tiger mosquito) and *Aedes aegypti*-Yellow fever mosquito) have already been found in Santa Barbara County, as well as Los Angeles and other metropolitan areas of California.

## **ECOLOGY**

There has been documented detections of PFAS compounds at non-hazardous municipal/residual waste landfills. Lang, J. R. et al., (2017)<sup>xxxiv</sup> study had shown that PFAS sampling at municipal landfills in California had common detections of PFAS compounds. The data on the two more common compounds showed that the combined concentrations of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) were well above the 70 parts per trillion recommended drinking water health advisories. As previously noted this comparison on leachate versus drinking water was just done for relative potential visualizations. Note that the landfills represented three climate conditions and old and new wastes. The focus of this should be that this study has shown PFAS compounds documented at relatively high levels in landfill leachate. There have been other studies provided that also complement this argument.

This information might imply that not only would PFAS compounds be in the landfill leachate but also in treatment center discharges if not specifically treated for these compounds. The above arguments should provide adequate rationale for PFAS testing of leachate at appropriate leachate locations not limited to the post treatment location where treated leachate goes to municipal wastewater treatment facilities. This sampling would also be recommended for proposed discharge areas at the local surface water locations. The rationale would be to have “adequate” baseline data on existing conditions prior to any approval and implantation of local creek discharge. The references for these bullets and the more detailed past correspondences are provided for review and consideration.

The recent Interstate Technology and Regulatory Council (ITRC) Per- and Polyfluoroalkyl

Substances (PFAS) Technical and Regulatory Guidance Document was updated and issued on April 14, 2020. This provides relevant and recent guidance on sources and remediation of PFAS compounds. The particular emphasis on Section 2.5 PFAS Uses. Table 2-4. Sample historic and current uses of PFAS has been summarized with respect to applications “Building and Construction”, “Household Products”, and “Textiles” with regard to materials that could likely be found in construction and demolition waste. Additional applications on this table could also logically be found in municipal/residual waste landfills and “beneficial reuse” facilities. One additional concern noted on this table was “oil production” and “mining” that might have some effect on PFAS found in the Marcellus or mining (coal or non-coal) remediation sites

The significance of these reports regarding wastes considers the lack of data on discharges from landfills and beneficial reuse projects. This could be a significant ecological factor considering PFAS compounds have been found in both regulated non-hazardous landfills and suspected from various wastes of construction/demolition wastes at unlined “beneficial reuse” projects. The regulated landfill leachate may be treated on site or go to a wastewater treatment facility for treatment. However, PFAS compounds are not typically tested at the lined and unlined sites, and there is no data and evaluations that the wastewater treatment facilities that treat leachate would also treat these compounds. The treated leachate or untreated from “beneficial reuse sites” would discharge to local surface water bodies. This opens the concern that macroinvertebrates and fish may be affected as well as plants. Then the effects on ecological receptors that are also prone to potential diseases may be affected as well as unknown effects on the consumers of the aquatic plants and animals.

Ji, K. et al. (2008)<sup>xxxv</sup> researched to toxicity of PFOS and PFOA on two species of freshwater macroinvertebrates (*Daphnia magna*, and *Moina macrocopa*). and one species of fish (*Oryzias latipes*). Basically, the research utilized standard toxicity laboratory test procedures and noted that PFOS was more toxic than PFOA for the two species tested. The testing also noted “significant reproductive” changes in the macroinvertebrates, and changes in the offspring of the parent fish exposed to these PFAS compounds. Note that the abstract states that additional research was recommended.

Renner, R. (2009)<sup>xxxvi</sup> note that the source of PFOS and PFOA in the parts per million range on the soils was the result of using biosolids from a wastewater treatment plant on five-thousand acres of grassland used by beef cattle. This report notes that the source of the PFAS compounds might be from commercial or residential wastewater, and qualified that this problem may be rare or common due to the lack of investigations. The Food and Drug Administration (FDA) as well as the USEPA are concerned as the cattle consumes about one to eighteen percent of the dry intake as soil and sludge. The report does not provide any analytical results of organic tissue but notes the concern of these compounds in the food chain.

Possibly the human race would not be immune to the various factors of population ecology. Other species are limited in population rate of growth by density dependent and independent factors. The mosquitos mentioned in other sections are increasing their land due to temperature increases due to climate change. Humans tent to evolve ways to increase food production and counter extremes of temperature with technology. The technology and knowledge on infectious disease countermeasures and risk assessment on pollution has greatly assisted a continued quality of life at least in developing nations as humans continue to increase in numbers as resources for the total ecosystem continue to decrease. However, possibly the pandemics are one of the factors of the in to counter our exponential growth not unlike the same for other species.

## CONCLUSION

The potential for Zika diseases would not just be theoretical in the United States. McAllister, J. C. et al. (2020)<sup>xxxvii</sup> describe an outbreak in four "hot zones" in the Miami Dade area of Florida during 2016. The four clusters of Zika cases and the Aedes mosquito vector was researched by federal, state, and local health organizations. The control of the adult mosquito with adulticide and larvacide spraying, with public relations warnings particular with pregnant women controlled this outbreak. However, the point should be taken that a rare United States disease may be emerging due to climate change, land use, travel, and importation of animals in the near future. While Zika has been used as a prime example note that this illustrates the potential and documented rare infectious diseases that should be prepared for this and new generations. While doing this paper the degree of professional papers on emerging diseases, the current COVID19 pandemic, and PFAS chemicals appeared to have the referenced articles as the tip of the literal iceberg. There were many other articles that could be cited although many of these were on a peer level for epidemiologists and health professionals.

The point of this paper would not be to encourage a "gloom and doom, the sky is falling" type of reading atmosphere. The point should be to prioritize and discuss potential emerging diseases and how human and other receptors immune systems may be compromised by PFAS and possibly other chemicals of concern. The simple fact that remote receptors such as polar bears and whales have detectable levels of PFAS compounds should indicate that the environmental and ecological pathways and food chain receptors have been extensive. Advances in health care and access for all citizens as well as preparation and advances in knowledge of genetics, environment, and ecology will be issues that government and non-government entities should focus on for the benefit of generations here and in the future. Casadevall, A. (2020)<sup>xxxviii</sup> discuss the potential for novel infectious diseases due to climate change not just viral but also fungal. This paper states that our successes with past SARS coronavirus and other diseases discussed in the above section should not bring about an attitude of complacency. The medical community and political leaders should continue to prioritize surveillance, research, and therapeutics. This brief paper states very well the logical preparation for the current and future generations.

Sampling for PFAS compounds has been recommended for specific sites in Northeastern Pennsylvania (Mellow, J.S (2020)<sup>xxxix</sup>) that have no information on baseline levels in environmental media, and potential elevated levels from pathways of specific sites such as landfills, beneficial reuse sites, and wastewater treatment plants. Potential other sampling of facilities that historically or presently use common PFAS products should also have characterizations. The problem that would not be limited to Pennsylvania would be the lack of data at high suspect sites. The recommended but not regulatory enforced concentrations might also be a problem with the attitude on “What do we do if we find it?” type of government philosophy. Many environmentalists still would believe that having adequate “background” data and biased suspected source(s) data would allow for reasonable technical decisions. The changes in risk based levels and research into analytical techniques should also continue to be evaluated. While Teflon would be an issue, one factor to note would be that most sampling equipment and the typical construction of monitoring wells recommends Teflon construction of various equipment and casing parts in contact with the environmental media. Considering that current risk levels are in the very low parts per trillion range, this should be a significant concern on the sampling effects and quality control/quality assurance samples could minimize and evaluate this possible effect.

The PFAS and relation to infectious diseases also interacts with other significant issues not limited to food security, climate change, overpopulation, land use competition, health care, and even potential reasons for future armed conflict. Hopefully science, economic, social, and political factors will work to resolve differences and resolve potential solutions for society. The point would be not to panic with no solutions but continued research and evaluation. While treatment techniques are still being evaluated, there should still be remediation of PFAS contamination and tackling of infectious disease recurrences due to mutations or other factors even if approaching the equivalent of a high stakes “Whac-A-Mole” game utilizing available science on best available technology. The “Whac-A-Mole” logic also should note that shorter chain replacements of PFAS should not necessarily be commonly substituted if there is still research going on that suggests there are still serious health concerns. The mole popping out of the new hole from the liner of fast food and pizzeria packaging should not be the next revelation for another generation to start to worry about. The recent online conversation with long-time environmentalist noted a simple three word conclusion that would tie up the verbose text.

***“Awareness is Key!<sup>xl</sup>”***

-Joseph Murphy, hard core environmentalist

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