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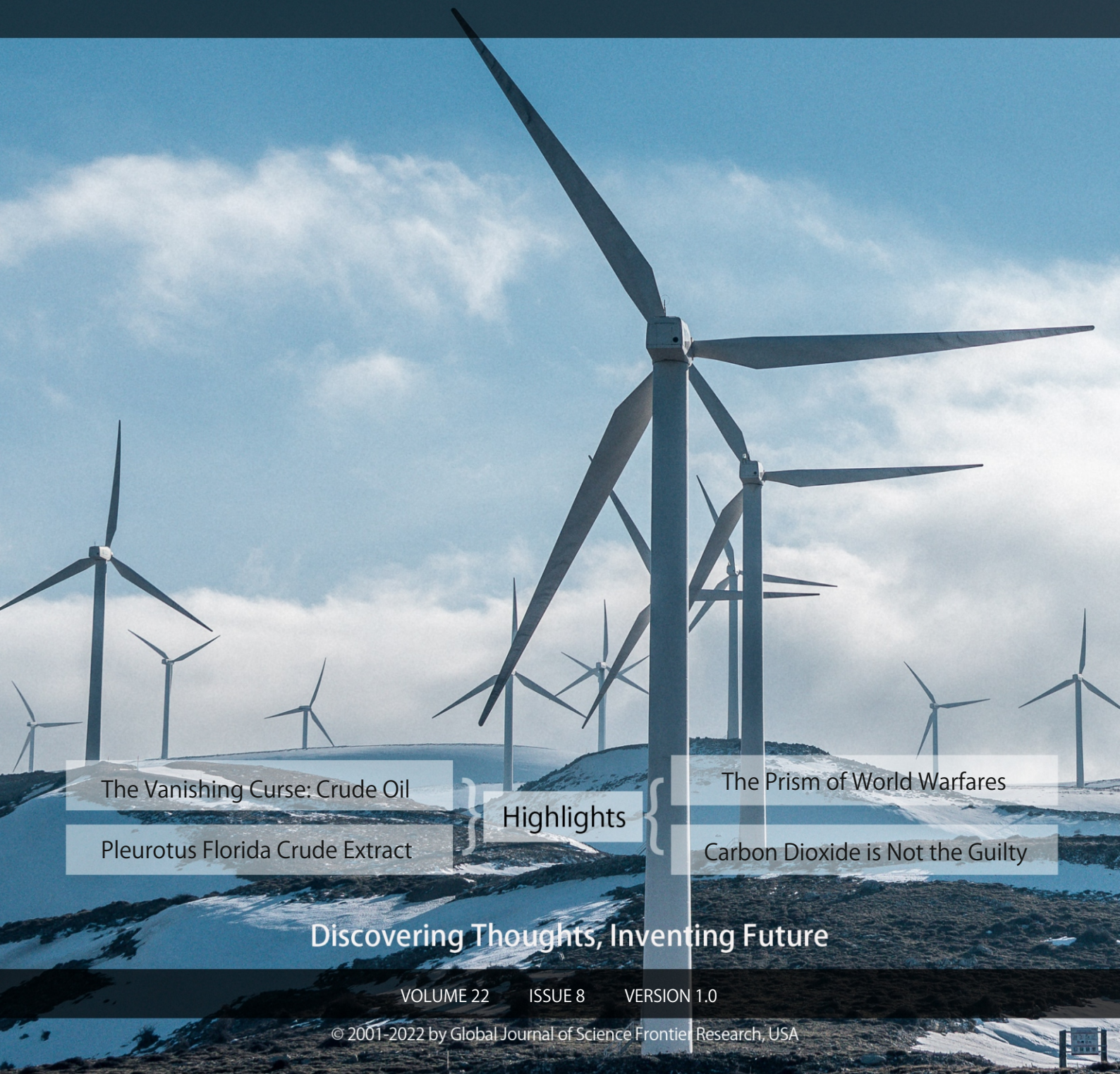

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Discovering Thoughts, Inventing Future

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The Vanishing Curse: Crude Oil

By Elie Elhadj

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I. Introduction

Politicians, investors, lenders, and executives in oil, gas, coal, car-making, fossil fuel power plants, and oil exporting countries, have been standing in the way of sustainable energy. Using all the tactics previously mastered by the tobacco industry, they have been leading a fierce and effective crusade to discredit climate science and the 97 percent of actively-publishing climate scientists who attribute greenhouse gas emissions and global heating to human activity. [1] They have been lobbying politicians to delay, water down, and even repeal sensible environmental laws, while propagating an image of themselves as being green and committed to renewable energy.

The first US federal legislation involving air pollution was almost seven decades ago: The Air Pollution Control Act of 1955. "It provided funds for federal research in air pollution."It was followed by The Clean Air Act of 1963.This was the first federal legislation regarding air pollution *control*. "It established a federal program within the US Public Health Service and authorized research into techniques for monitoring and controlling air pollution." [2]

Alarm bells were sounded in 1965, when President Lyndon Johnson released for publication a 317-page report of the Environmental Pollution Panel of the President's Science Advisory Committee titled: "Restoring the Quality of Our Environment."[3] The Report warned that "large-scale fossil fuel burning is increasing CO2 in the atmosphere well beyond normal levels. The result will likely be major changes to the earth's climate."[4]

In 1967, the Air Quality Act initiated enforcement proceedings "in areas subject to interstate air pollution transport."On December 2, 1970, the US Environmental Protection Agency (EPA) was created. At approximately the same time, the enactment of the Clean Air Act of 1970 authorized "the development of comprehensive federal and state regulations to limit emissions from both stationary (industrial) sources and mobile sources."The 1970 Act was amended in 1977 and 1990. [5].

Exxon Mobil, the world's biggest oil company, knew of climate change long before it became a public issue. However, the company spent millions of dollars to promote climate denial. [6] In Europe, topping the list of firms obstructing climate action is British Petroleum, [7] Notwithstanding the green logo it designed in 2000 to propagate a positive environmental image of itself. [8] BP, Shell, ExxonMobil, Chevron, and Total spend US$200 million a year lobbying to delay, control or block policies to address environmental damage. [9]

Mounting evidence of global heating, from melting glaciers to more intense heat waves, droughts, longer wildfire seasons, and bigger, stronger hurricanes are brushed aside as normal variations in weather pattern by climate change deniers among politicians and their benefactors in the banking, auto making, and fossil fuel industries. There are those who accept that global heating is real, but deny human responsibility, therefore efforts to forestall climate change will be futile. There are those who claim that global heating is beneficial because it will make parts of the earth more habitable, ignorant that many more parts would become uninhabitable and that annual losses due to, for example, heat-induced labour productivity alone may be estimated at over two trillion dollars, as will be discussed later.

Despite environmentalists' activism against the use of crude oil and the price-competitiveness of solar and wind electricity generation in recent years, global demand for oil between 1972 and 2021, increased by 84 percent, to 94 million barrels per day, [10] of which 42 million barrels per day were exported. In 1950, global oil demand was a mere 10 million bbl./day. [11] Significantly, the transport sector accounts for the lion's share of global oil consumption. In 2019, the International Energy Agency (IEA) estimated that the transport sector consumed 65.3 percent of global demand for crude oil, while other uses added up to 34.7 percent, as Table 1 shows: [12]

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Table 1: Share of Crude Oil Final Consumption (2019)

Transport	%	Other	%
Road	49.2	Non-energy	16.7
Rail	0.8	Residential	5.3
Navigation	6.7	Industry	7.3
Aviation	8.6	Misc.	5.4
Total	65.3	Total	34.7

Source: IEA

Environmentalists' struggle over the past four decades suddenly benefited from a serious boost on February 24, 2022, from an unexpected quarter—Vladimir Putin's invasion of Ukraine. The war has finally awakened European public and politicians, and Germany in particular, to the national security risks of relying on Russia's oil and gas. It is disconcerting that protecting the environment had to wait for Russian realpolitik and Ukrainian blood to gain momentum. In Europe, Mr. Putin's war spurred a determined effort to transition from oil and gas to sustainable energy sources and from petrol cars to electric vehicles in order to protect European national security. In the United States, while Russian oil and gas are not needed, the shift to sustainable energy sources would weaken the Kremlin's spending on its war machine—36 percent of Russia's total budget for 2021 came from oil and gas. [13] President Biden's $370 billion in clean energy investment serves US national security interest. It will hasten the day of making the internal combustion engine obsolete and help collapse the global demand for oil.

II. The Politics of Hegemony Over Global Oil Exports

Oil hegemony in a world addicted to crude oil means world hegemony. While the US might not need Saudi oil, [14] it may be argued that effective American control over the oil fields of the world's biggest oil exporter and swing producer, along with those of the five other Gulf Cooperation Council (GCC) members, has been important to US national security for two reasons. The first is to avert serious disruptions of oil shipments to US allies, like Japan, which could cripple global supply-chains and damage US industry and national security. The second reason is to enable Washington to control most of global oil exports and weaponize such control as a non-lethal weapon of mass destruction in the event of war against America's rivals, in particular, China.

The catastrophic consequences of the oil weapon on the national security of energy importing countries was made clear 40 years ago in a 24-page report prepared by the Central Intelligence Agency for former President Ronald Reagan titled "USSR-Western Europe: Implications of the Siberia-to-Europe Gas Pipeline." [15] It advised Mr. Reagan in 1981 of the serious political and military risks involved in the construction of a giant gas pipeline from Russia to Germany. Describing the document, *The New York Times* wrote: "The language in the C.I.A. memo was unequivocal: The 3,500-mile gas pipeline from Siberia to Germany is a direct threat to the future of Western Europe, it said, creating 'serious repercussions' from a dangerous reliance on Russian fuel." [16] Former President Donald Trump, stressed during a visit to NATO Headquarters in Brussels on July 11, 2018, that a gas pipeline, supposedly the undersea Nord Stream 2 pipeline, from Russia to Germany has made Germany "totally controlled" by and "captive to Russia." [17]

Saudi and GCC oil fields are critical to the control of much of global oil exports and pricing. They contain around a third of the world's reserves and a quarter of annual oil production. [18] They are among the least costly to extract and relatively easy for US forces to protect. They are located on a rather small geographic area of some 800 miles along the Eastern Coast of the Arabian Peninsula. The size of the native population in the oil-rich areas is small, ruled by Sunni absolute emirs, kings, and sultans, troubled by a powerful neighbour like Shi'ite Iran and eager for US protection.

American interest in crude oil has protected Saudi and GCC rulers for decades despite their non-representative, non-participatory, and non-transparent governance. They stay in office for life until they die of natural causes, get assassinated, or are removed in a palace coup. The palace ulama (Islamic priests) teach that blind obedience to the Muslim ruler is obligatory: a form of piety, even if the ruler is corrupt and unjust. They invoke Qur'anic Verses and Prophetic Traditions to threaten hell's fire to those who might be tempted to disobey the king. It is far simpler for Washington to manage a few absolute leaders rather than deal with the scores of parliamentarians and political leaders of democratic settings. While the size of the families of the rulers of Bahrain, Kuwait, Oman, Qatar, and the seven emirates that make up the United Arab Emirates (UAE) are small, the Saudi ruling family is possibly the largest the world has ever known—more than 11,000 direct descendants of King Abdulaziz, the founder of the dynasty (2018 estimate). When the families of Abdulaziz's brother and the half-dozen half-brothers are added, the extended family might grow to 15,000, or more. [19] In such a huge family, only a small number of

trusted family elders counsel the king and run the important ministries, while the rest enjoy generous stipends and act as eyes and ears of the regime.

Moreover, to prevent the slightest whiff of democratic wind that might blow in the direction of the Arabian Peninsula, the US has tolerated the illegitimate, brutal, and corrupt military dictatorships in the Arab Levant, Egypt, and Yemen since the early 1950s. Like their royal counterparts, the presidents rule for life, until they die of natural causes, get assassinated, or are removed in a military putsch. Also, the army's ulama demand blind obedience to the president regardless of his bad deeds. In Cairo, Baghdad, and Damascus, the generals distinguish themselves, however, by conducting uncontested referendum theatrics, with near 100 percent farcical "yes" results.

Washington protected the al-Sauds after two major events during the past fifty years that injured the United States. The first was in October 1973, when Riyadh led the oil boycott by the Organization of Arab Petroleum Exporting Countries (OAPEC) of countries that supported Israel during the Arab-Israeli War, and as a result oil prices were quadrupled to $11.65 a barrel the following January 1974. [20] The second event was September 11, 2001, when fifteen of the nineteen Wahhabi terrorists who flew passenger airplanes into buildings in New York City and Washington D.C. turned out to be Saudis, the G.W. Bush administration would not retaliate against the hotbed of Wahhabism. [21] Instead, it demolished much of Iraq in 2003, perhaps because Iraq's relatively small oil exports were less disruptive to global oil flows than Saudi Arabia's. Or, perhaps Iraq could have become a launching pad to overthrow the Ayatollah's regime in Tehran, impose a pax Americana on the Middle East, and break up OPEC. In the event, however, wittingly or unwittingly, by crippling Iraq, Mr. Bush handed Iraq to Iran, giving rise to the Shi'ite Crescent from Iran to Iraq, Syria, and Lebanon, and Yemen.

The empowerment of Iran has made Qom (the religious capital of the Supreme Ayatollah), act as if it were the Vatican of world's Shi'ites and the defender of their causes. Iran, a large; powerful country of 86 million people causes unease in Saudi Arabia, a smaller country of 33 million people, ten million of whom are expatriate workers, comprising 75 percent of the Saudi work force. [22] The empowerment of Iran opened the gates of hell between Islam's two intractable enemies: Persian-speaking Shi'ite Iran and Arab-Sunni Wahhabi Saudi Arabia. Shi'ites regard Sunnis as usurpers of the caliphate from Prophet Muhammad's cousin and son-in-law, Ali bin Abi Talib, after the death of the Prophet in 632, whereas Wahhabism regard the Shi'ites as heretics. [23] Indeed, Riyadh treats its own Shi'ite minority as second-class citizens. They live in the oil producing areas in the Eastern Province, across the Gulf from Iran. Their mistreatment goes beyond religious discrimination due to a fear that Saudi Shi'ites are more loyal to Iran than the al-Sauds. Iran's newly found power exploded Saudi/Iranian proxy wars that have devastated Iraq, Syria, and Yemen and resulted in the sale of tons of American weapons to Saudi Arabia and the five other GCC states. Lebanon has practically become a colony of Iran, thanks to Hezbollah. It is likely that the Sunni/Shi'ite wars will burn for generations to come.

Over the decades, Washington has protected the al-Saud regime quietly and with discretion. Likewise, Saudi officials have kept to their non-transparency in government business. Former President Donald Trump, however, broke with diplomatic discretion. At a rally in Southaven, Mississippi on October 2, 2018, the former president disclosed that he told King Salman: "King — we're protecting you — you might not be there for two weeks without us." [24] Even South Carolina Republican Senator Lindsey Graham said in December 2018 that, Saudi Arabia's military "can't fight out of a paper bag" and, "if it weren't for the United States," he continued, "they'd be speaking Farsi in about a week in Saudi Arabia." [25]

III. Guarding the Oil Fields, Shipping Lanes, and Royal Palaces

The United States Stations some 40,000 troops around the Gulf region. They ensure the un-interrupted flow of some 17 million bbl./day (including oil exports from Iran and Iraq), through the choke-point of the Strait of Hormuz. They protect the oil fields and GCC rulers.

Bahrain is home to the US Fifth Fleet, hosting approximately 7,000 personnel. Its Khalifa bin Salman deep-water port can accommodate aircraft carriers. Out of Sheikh Isa Air Base, the US Air Force operates fighter and surveillance aircrafts. [26] In Kuwait, approximately 13,500 US forces are mainly at Camp Arifjan and Ali al-Salem Air Base. Only Germany, Japan, and South Korea host more US forces than Kuwait does. Since 2004, Kuwait has been designated as a Major Non-NATO ally. [27] In Saudi Arabia, until 2003, the US maintained a large air force presence at the Prince Sultan air base outside Riyadh. In a cosmetic move, it relocated to the nearby al-Udeid Air Base in Qatar. The move was intended to "purify" the land of the two holy mosques of Mecca and Medina from the military presence of "infidels" to calm bin Laden's followers. Currently, US troops in Saudi Arabia number around 2,700. [28] In Qatar, Al-Udeid Air Base is a few minutes flying time from Saudi Arabia's Eastern Province where all Saudi oil fields are located. With around 10,000 US troops and 120 aircrafts, al-Udeid is the largest US base in the Middle East. [29] It is indispensable to supporting US military operations throughout the region, and according to the State Department, Qatar has contributed since 2003, more than $8 billion in developing al-Udeid. [30] The UAE hosts the Gulf Air Warfare Centre at Al Dhafra

Air Base, where approximately 3,500 US personnel are based. UAE ports also provide critical logistical support for the US Navy. [31]

Out of a global oil production in 2021 of 94 million bbl./day, 42 million bbl./day is exported (see the Introduction). Saudi Arabia's share is 18 percent. The share reaches around 30 percent when the oil exports from Kuwait, Oman, Qatar, and UAE are added. [32] In the event of a war between the US and its oil importing rival(s), especially China, the rich oilfields of Southwest Iran and Southern Iraq could come under the control of the American armada, raising the proportion of global oil exports under American control to around 50 percent. [33] In such an event, the US is also in a position to control another eight million bbl./day from Canada, Columbia, Mexico, Venezuela, Norway and the United Kingdom. [34] In all, the US may count on two thirds of global oil exports. The corner stone of its oil weapon, however, is the Middle East.

What will be the case when the sale of new petrol cars is banned? Since the transport sector burns some 65 percent of the global demand for oil (see Table 1), Russia would lose considerable oil income; Saudi Arabia and the other five GCC states would ultimately become impoverished, and the US would lose the oil weapon from its arsenal.

IV. Manifesting US Protection of Saudi Arabia

In addition to its military presence, US defence of Saudi Arabia is manifested in two ways. First, American weapons and technicians keep the hundreds of billions of dollars-worth of sophisticated US weapon systems sold to the Saudi Ministry of Defence and Aviation and the National Guard over the past half a century in good operational order. Weapon purchases may be described as a form of protection money. According to the Saudi Central Bank, between 1981 and 2017, Saudi defence and national security received the highest allocation of annual budgets: $1.1 trillion out of $3.36 trillion in total revenues from crude oil exports. [35] It may be guesstimated that spending on US weapons might have been in the region of 50% of the defence budget. The Obama administration, for example, sold Riyadh in a single deal in 2012, $112 billion in weapons over eight years. It also had another $110 billion package under negotiation before the Trump administration took office. [36]But, to Mr. Trump these billions were insufficient. He told a rally in Wisconsin on April 29, 2019, "We are losing our ass defending you, Saudi Arabia." [37]

Secondly, US protection of the al-Sauds is also aided by former senior Washington administration officials, captains of industry, media moguls, and professional lobbyists who act for the Saudi government, ruling family members, and Saudi private sector in return for hefty fees. Politico reported that the Centre for International Policy "found that registered foreign agents working on behalf of Saudi interests contacted Congress, the White House, the press and think tank analysts more than 2,500 times in 2017." [38] The New York Times reported that six months after leaving the White House, Jared Kushner, Donald Trump's son-in-law and former senior adviser in the White House, secured a $2 billion investment from the Saudi Public Investment Fund despite objections from the fund's technical advisers about the merits of the deal, such as, its excessive investment risk, high fees, and the inexperience of the Kushner management team. [39] The objections were overruled by the Fund's full board, led by Crown Prince Mohammad bin Salman (MBS).Also, former Treasury Secretary Steven Mnuchin was given an investment from the Saudi Fund, though not as large, or on terms as favourable, as Mr. Kushner's. [40]

Since 2004, Saudi Arabia has been designated by the US State Department as a "Country of Particular Concern" (CPC) under the International Religious Freedom Act of 1998 for having engaged in or tolerated particularly severe violations of religious freedom. On February 29, 2016, the Secretary of State re-designated Saudi Arabia as a CPC and announced a waiver of the sanctions that accompany this designation as required in the important national interest of the United States. [41]

As long as the demand for oil imports by China, Europe, India, Japan etc. is strong, the US will tolerate the al-Saud regime. As would be expected of a rich but militarily weak country surrounded by enemies, especially since Ayatollah Khomeini established the Islamic Republic of Iran in January 1979, Saudi Arabia became particularly accommodating in its dealings with Washington. Alongside the US, Riyadh actively supported the Iraq/Iran war (1980-1988). [42] During Iraq's occupation of Kuwait (1990-1991), Saudi Arabia hosted some 800,000 troops (more than 540,000 from the United States) to liberate Kuwait. [43] Also, during the USSR war in Afghanistan (1978-1992), Saudi and American support of the mujahideen defeated Moscow. [44]

With the history of US-Saudi cooperation, it is curious that the Saudi Crown Prince, Muhammad bin Salman (MBS), decided that OPEC should cut oil production by 2 million bbl./day, one month before the US mid-term congressional elections on November 8, 2022. [45] The act was described by White House officials as "hostile." [46] It was clearly intended to hurt Mr. Biden's Democratic candidates and help Mr. Trump's Republican candidates. Judging from MBS' past behaviour, it was his way to retaliate against Mr. Biden's release on February 26, 2021, of a report by American intelligence agencies dated February 11,

2021, that MBS approved the planned assassination of Jamal Khashoggi. [47] By contrast, Mr. Trump boasted that he saved Saudi Arabia's crown prince from Congress over the killing of the journalist. "I saved his ass" Mr. Trump told author Bob Woodward for his book "*Rage.*" [48] Needless to say that the Crown Prince's behaviour will damage Saudi interests. Such conduct, however, is consistent with MBS' short sightedness, volatility, brutality, and recklessness ever since his father, King Salman, handed him high office in June 2017.

V. Former President Trump's Assault on Environmental Regulations

We have seen in the Introduction that the United States government has led the way in environmental protection legislation: The Air Pollution Control Act of 1955; Clean Air Act of 1963; Air Quality Act of 1967; Clean Air Act of 1970 and its amendment in 1977 and 1990. And, in order to implement the various requirements included in these Acts, the National Environmental Policy Act established the Environmental Protection Agency in 1970. Notwithstanding American commitment, Mr. Trump, nonetheless, asserted on Twitter on November 6, 2012, four years before he became President of the United States, that: "The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive." [49]

In his first 100 days in office, Mr. Trump reversed 23 environmental rules. [50] The consequences of such actions are serious. For example, by revoking the rule that prevents coal mining companies from dumping debris into local streams (February 16, 2017) and ending the ban on a potentially harmful insecticide (March 29, 2017), he improved corporate profits and the stock values of the companies involved, while the burden of cleaning the polluted rivers and reclaiming the contaminated soil is shifted to future generations.

In the middle of 2017, the US Interior Secretary directed the Bureau of Land Management to ramp up sales of oil and gas leases on federal land in order to increase oil production on federal lands. [51] In a sign of what was to come, "Trump Digs Coal" placards became a common sight in Trump's rallies in America's coal states. On a visit to West Virginia on August 21, 2018, Mr. Trump declared: "We love clean beautiful, West Virginia coal ... That's indestructible stuff ... In times of war, in times of conflict, you can blow up those windmills, ... You can blow up those pipelines ... You can do a lot of things to those solar panels ... But you know what you can't hurt? Coal." [52] Speaking at a National Republican Congressional Committee dinner on April 2, 2019, Mr. Trump went as far as declaring that "wind farms cause cancer" [53] and in an interview on October 15, 2018, with CBS's program *60 Minutes*, he accused climate change scientists of having a "political agenda." [54] He doubted whether humans were responsible for earth's rising temperatures, adding that temperatures "could very well go back," and that he does not want "to give trillions and trillions of dollars" and "lose millions and millions of jobs." [55]

On August 4, 2017, the Trump Administration notified its intent to withdraw from the 2015 Paris Climate Agreement [56] and the US became the only country in the world outside the landmark Paris Agreement. [57] Subsequently, at the UN Climate Change Conference in Katowice, Poland in December 2018, the United States joined Kuwait, Saudi Arabia, and Russia in objecting to the report by the Intergovernmental Panel on Climate Change on the impacts of a temperature rise of 1.5 centigrade. This unusual coalition and action by the United States was shocking to scientists and many delegates at the conference. [58]

VI. What Might Be Lurking Behind Mr. Trump's Denial of Climate Change?

It might be Mr. Trump's wishful thinking to prolong the life of America's oil weapon against China, even though, Beijing is actively electrifying its transport fleet, which would stop the sale of new petrol cars and seriously reduce its oil imports in about two decades (see below: Which Country Will Lead the Drive Towards Electric Cars). It might be that the transition from fossil fuel to green economy will inevitably see setbacks, and Mr. Trump cannot tolerate setbacks. On the campaign trail, Mr. Trump often told his followers: "We're going to win so much, you're going to be so sick and tired of winning." [59] Further, it might be that the transition to green economy requires the writing off the value of expensive smoke-stack assets and making major investments in green replacements, which neither Mr. Trump nor his benefactors in the energy, auto, and banking industries would accept.

Just like the motor car and the light bulb, which replaced the horses and candles and kerosene lamps, so the internal combustion engine and coal-fired power plants will be superseded. Mr Trump's attitude toward global heating would keep the US stuck with old technologies and polluting industries. It would deny US industry the potential of trillions of dollars in export revenues and millions of well-paid jobs. Trumpian politics would "make US manufacturing non-competitive."

VII. Transition from Fossil Fuel to Green Energy

British Petroleum estimated in 2014 that "the Earth has enough oil left for about 53 more years at current production levels," but "significantly more than

53 years of oil remaining if drilling technologies can improve to the point that recovering the more difficult to reach oil becomes economically feasible." [60] The electric vehicle (EV), however, has changed the arithmetic. It has made future availability of oil a function of demand, not supply or oil reserves. The rapidly growing green consciousness around the world will pressure politicians to accelerate the momentum towards zero greenhouse emissions. Combined with new green technologies, it will determine how much of the earth's oil reserves will be left in the ground.

The green revolution will progress over two stages. The first would see the EV cutting global demand for crude oil between 2030 and 2040, possibly by up to two-thirds (see Table 1). The second stage would end the demand for natural gas and coal over a considerably longer duration of time, possibly a century, or maybe longer.

VIII. The First Stage

National security concerns in China, Europe, India, and Japan, among others, will spur the electrification of their transport fleets and, within the next two decades, oil demand is expected to drop considerably. Ultimately, two-thirds of the current 42 million bbl./day in oil exports (see above: Guarding the Oil Fields) would disappear, leaving exports of 14 million bbl./day for non-energy uses, like industrial; pesticides; fertilizers; plastics; chemicals, etc. Clamouring for revenues out of a much smaller pie, the market price for oil would collapse. Countries with the lowest production costs will be in a position, theoretically, to drive higher cost producers out of the market. OPEC would be disabled. Wars among the oil exporters cannot be ruled out. Table 2 shows the overall costs in eight countries to produce a barrel of oil or gas equivalent (production + administrative/ transportation + capital spending + gross taxes). [61]

Table 2: Cost to Produce a Barrel of Oil or Gas Equivalent ($/bbl. - 2016)

Iran	Saudi Arabia	Iraq	Russia	Indonesia	US (non-shale)	Nigeria	UK
9.1	10.00	10.6	19.2	19.7	21.00	29.00	44.3

Source: knoema

The impact would be particularly severe on Saudi Arabia. In its country report on Saudi Arabia, the IMF wrote: "Oil revenues averaged 75 percent of total budget revenues since 2010, with large variations, peaking at 93 percent in 2011 and falling to 53 percent in 2020 as the COVID-19 crises pushed global oil demand down." [62]

Ultimately, the first stage will see Saudi oil exports diminishing to a trickle. When that happens, US protection will come to an end; Wahhabi indoctrination and proselytization will falter; terror groups will be weakened and democracy could finally be born in the countries of the Arab Levant and Egypt. The EV would have contributed to promoting democracy and fighting terror, possibly more than the bombing of terrorists' hideouts.

Painting a different picture, Saudi Arabia's Minister of Energy, said in October 2017, "Energy demand is expected to rise by about 45 percent by the year 2050... [renewables] will only account for about 10 percent of the primary energy demand... Petroleum, natural gas, and coal will continue to account for about 75 percent of the supply of energy by 2050. [63]

The International Energy Agency's Electric Vehicles Report of September 2022 provide an optimistic account of the rapidly increasing momentum of the EV. [64] Compared with 2020, global electric car sales in 2021 nearly doubled, to 6.6 million, or about 9 percent of total car sales, bringing the total number of electric cars on the road to 16.5 million. The IEA estimates that in 2022, the global EV sales share will be around 13 percent. It also estimates that the numbers of EVs in 2030, would reach more than 300 million, accounting for 60 percent of new car sales. At the United Nations Conference of the Parties (COP26) in Glasgow, UK in late 2021, more than 100 stakeholders including governments, automakers, investors, financial institutions and fleet owners and operators committed to accelerate the transition to 100 percent zero-emission cars and vans globally by 2040, and by no later than 2035 in leading markets. [65]

In 2021 and 2022, major automakers announced plans to electrify their products: Toyota will have 3.5 million annual electric car sales by 2030; Volkswagen's sales of all-electric vehicles by 2030, will exceed 70 percent in Europe and 50 percent in China and the US, and by 2040, nearly 100 percent will be zero emission vehicles. One third of Ford's sales will be fully electric by 2026 and 50 percent by 2030, with all-electric sales in Europe by 2030; at BMW, 50 percent of vehicles sold will be fully electric by 2030 or earlier; Volvo will become a fully electric car company by 2030; at Mercedes, all newly launched vehicles will be fully electric from 2025. General Motors will have production capacity of 1 million units in North America of 30 EV models and battery electric vehicles (BEV) by 2025, plus carbon neutrality in 2040.

IX. Which Country Will Lead the Drive Towards Electric Cars?

The IEA Report noted that Chinese multinational holding company, Geely announced that 20 per cent of sales will be electric by 2025. Probably, China will lead the race towards electric cars. In 2021, EV sales were 3.3 million (tripling 2020 sales), representing 50 percent of global EV sales. Between January and October 2022, 4.63 million EVs were registered, with about 6 million units forecast by the China Passenger Car Association for the whole year. [66] The rapid growth in EV sales in China is driven by both consumer demand and policy incentives: government investment in charging infrastructure, supply chain inducements, and parking and license plate privileges. [67]

Electrifying China's transportation sector will enhance China's national security by reducing the country's reliance on politically and militarily risky oil imports. It is notable that 1993 was the first year in which China's crude oil consumption exceeded its domestic production. [68] Table 3 shows that in 1993, a small volume of 90,000 bbl./day was imported. By 2016, however, what started as a trickle, has become a flood—7.89 million bbl./day.

Table 3: China's Crude oil Consumption and Production (1993 – 2016) –Thousands bbl./day

	1993	1995	2000	2005	2010	2014	2016
Consumption	2,993	3,394	4,689	6,970	9,339	11,637	12,792
Production	2,903	3,060	3,389	3,871	4,575	5,045	4,905
Imports	90	334	1,300	3,099	4,764	6,592	7,887

Source: Worldometer

In 2020, China imported a record10.853 million bbl./day, or 25 percent of global crude oil exports (see above: Guarding the Oilfield). [69] In 2021, the volume dropped to 10.301 million bbl./day. [70] While Covid 19 could have contributed to the drop, tripling EV sales in China in 2021 certainly added to the drop in crude oil imports. In each of June and July 2022, 8.8 million bbl./day were imported, the least since July 2018, but increased to 9.5 million bbl./day in August. [71] For the first 11 months of 2022, imports stood at 10.06 million bbl./day. [72]

China's crude oil consumption in 2021 was 15.442 million bbl./day. [73] Assuming that it follows the IEA pattern in Table 1, (road transport 49.2 percent, rail 0.8 percent, navigation 6.7 percent; aviation 8.6 percent) and all internal combustion-engines are replaced by EVs, then China would be able to save 7.6 million bbl./day on road transport [74] and 2.48 million bbl./day on rail, navigation, and aviation [75] for a total saving of 10.08 million bbl./day, more or less equal to China's oil imports in 2021. It may be concluded from the data that China's oil imports are used to fuel the country's transport sector, and its domestic oil production is used to meet its non-transport needs. Said differently, for China to free itself from crude oil imports, it must abandon the internal combustion engine.

Europe is following China in shifting to electric vehicles with 2.3 million units sold in 2021, an increase from 1.4 million in 2020. During the first ten months of 2022, 1.9 million EVs were registered in Europe, about 21% of the total volume. [76]In Norway, electric cars were almost 80 percent of the cars sold in 2022. [77] The shift in Europe is expected to accelerate in reaction to Russia's war against Ukraine.

In the United States, electric car sales doubled their market share to 4.5 percent in 2021, reaching 630 000 units sold. On August 5, 2022, President Biden outlined an ambitious target of "50 percent EV sales share in 2030, to unleash the full economic benefits of his Build Back Better agenda and advance smart fuel efficiency and emission standards… Positioning America to drive the electric vehicle future forward, out compete China, and tackle the climate crisis." [78]

X. The Second Stage

The second stage would end the demand for natural gas and coal and will benefit the environment. However, it will take a long time. In 2021, fossil fuel provided 63.3 percent of the energy needed globally for electricity generation, with the remainder generated from renewable sources as Table 4 shows: [79]

Table 4: Electricity Generation Mix (% - 2021)

Oil	Gas	Coal	Solar	Wind	Nuclear	Hydro	Other renewables
3.1	23.5	36.7	2.7	5.3	10.4	15.8	2.5

Source: Our World in Data

De-commissioning coal and gas-fired electricity plants will be very slow. Power plants are typically depreciated over fifty years. Globally, there are more than 2,400 coal-fired power plants operating in 79 countries. [80] Since 2000, coal-fired capacity has doubled, thanks to explosive growth in China and India. In 2019, China produced almost one half of coal-generated electricity in the world. [81] In 2019, there

were 1,600 coal-fired power plants under construction. [82] In 2021, China's share of coal power stations under construction around the world was 52 percent. [83].

Science is leading a rapid transformational revolution towards cheap renewable sources of energy to replace fossil fuel in power plants. Solar Photovoltaics (PV) and onshore wind are now "the cheapest sources of new-build generation for at least two-thirds of the global population, according to BloombergNEF. Those two-thirds live in locations that comprise 71% of gross domestic product and 85% of energy generation."

And "battery storage is now the cheapest new-build technology for peaking purposes." [84]At MIT, it was announced in December 2022, that engineers have developed ultra light solar cells, much thinner than a human hair, that can be glued to a fixed surface to quickly turn it into a power source. MIT News described the new solar cells as being "one-hundredth the weight of conventional solar panels, generate 18 times more power-per-kilogram, and are made from semi-conducting inks using printing processes that can be scaled in the future to large-area manufacturing." [85].

Another notable development is Green Hydrogen. For hydrogen to be green it must be produced from renewable energy sources. In order to separate the hydrogen from the oxygen, an electric current is passed through water electrolysers. The hydrogen gas is captured for use in a fuel cell to produce electricity to power vehicles, planes, ships, long-haul freight. [86] Standing in the way of large-scale green hydrogen developments is its high cost of production, storage, transport, and building an industrial supply chain. However, with declining costs for solar PV and wind generation, the IEA concluded: "Building electrolysers at locations with excellent renewable resource conditions could become a low-cost supply option for hydrogen, even after taking into account the transmission and distribution costs of transporting hydrogen from (often remote) renewables locations to the end-users." [87]

Nuclear fusion promises limitless clean energy to end dependence on fossil fuels. Scientists studying fusion energy at Lawrence Livermore National Laboratory in California announced on December 13, 2022, that they had crossed a major milestone in reproducing the power of the sun in a laboratory when they bombarded a fuel pellet of the heavier forms of hydrogen (deuterium and tritium), resulting in a net energy gain. [88]

XI. Resistance to Writing-off Trillions of Dollars

Standing in the way of renewable energy is the opposition of shareholders, bank lenders, and bond holders to writing-off trillions of dollars in the value of privately owned companies in oil, gas and coal mining, oilfield services, pipelines, tankers, barges, ships, railroad cars, delivery trucks, gasoline stations, fossil fuel power plants, auto makers, and the myriad of equipment manufacturers to these and supporting industries. Governments would also object to writing-off the drop in the values of operational publicly owned assets of these same industries.

In the UK alone, reducing greenhouse gas emissions to net zero could cost an estimated £1 trillion, according to former Chancellor of the Exchequer, Philip Hammond. [89] In the United States, estimates vary wildly. Former President Trump claimed in a speech at a rally in El Paso, Texas on February 13, 2019, that the Green New Deal to transition to 100 percent green energy in the US, proposed by Representative Alexandria Ocasio-Cortez and Senator Edward Markey on February 7, 2019, could cost $100 trillion. A syndicated columnist for The *Washington Post* estimated a low of $46 trillion and a high of $81 trillion. [90] To put the price of saving the environment in perspective, however, the cost of saving bankrupt banks in the US alone, in the aftermath of the 2008 financial meltdown, exceeded $22 trillion. [91] And, while funding the bankrupt banks had to be done quickly, the cost of saving the environment will be spread over decades.

XII. The Gargantuan Cost of Inaction

Global heating causes illnesses from polluted air and oceans, higher death rates from more frequent harsher weather, damage to property and infrastructure, rising sea levels, drowning of coastal cities, loss of agricultural land, national security threats from mass migrations, and lower productivity and GDP growth. Annual losses due to heat-induced labour productivity alone were estimated at $2.1 trillion in 2017, and in several countries, labour productivity losses are equivalent to more than 10 percent of gross domestic product. [92]

A study of the public costs of climate-induced financial instability found that climate change will increase the frequency of banking crises. "Rescuing insolvent banks will cause an additional fiscal burden of approximately 5–15% of gross domestic product per year and increase the ratio of public debt to gross domestic product by a factor of 2." The authors estimate that "around 20% of such effects are caused by the deterioration of banks' balance sheets induced by climate change." [93]

Even if the probability of a connection between global heating and human behaviour is infinitesimally small the apocalyptic horror awaiting those parts of the earth that might become uninhabitable and the parts that might become severally inhospitable, should awaken climate science deniers to the toxic inheritance awaiting their grandchildren.

XIII. Preparing for the Looming Write-Offs

During the five years since the Paris Agreement in 2015, 60 of the world's largest commercial and investment banks have committed more than $3.8 trillion to the fossil fuel industry. [94]

The Bank of England was the first central bank to set supervisory expectations for banks and insurance companies on the management of climate-related financial risks for an orderly market transition to a low-carbon world. On September 29, 2015, it published "The impact of climate change on the UK insurance sector," followed on September 26, 2018, by "Transition in thinking: The impact of climate change on the UK banking sector." From 2022, the Bank moved towards actively overseeing regulated firms against its supervisory expectations. [95]

The US Federal Reserve Board announced on September 29, 2022 that in early 2023, six of the nation's largest banks will participate in a pilot climate scenario analysis exercise designed to enhance the ability of supervisors and firms to measure and manage climate-related financial risks. Climate scenario analysis is distinct and separate from bank stress tests. It is exploratory in nature and does not have capital consequences. [96]

The European Central Bank has launched a new climate change centre and is planning a climate stress test over a 30-year horizon to assess the impact of climate change under various climate scenarios on the counterparties of the European banking sector. [97]

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) was formed at the Paris One Planet Summit in December 2017. The group currently comprises 89 members and 13 observers. Its mission statement explains that its purpose is to "help strengthen the global response required to meet the goals of the Paris Agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development." [98]

XIV. A Post-Oil Middle East

a) *The Political Scene*

Washington would abandon an Arabian Peninsula without crude oil. And without US protection, Saudi and the other GCC rulers will be left on their own to face an uncertain future against a more powerful and hostile Iran. In a post-oil Middle East, a dangerous brew of religion and nationalism will polarize the Middle East more than ever before. There could be four different ethnic, religious, and sectarian powers vying for control: Sunni Turkey; a block of Sunni Arab states; a block of Shi'ites in Iran and certain Arab communities; and Jewish Israel. There can be as many scenarios of the shifting political alliances among these fervour-filled powers as the mind can conjure.

Israel's security will determine the politics and shape of the post-oil map. Sunnis and Shi'ites will be in a constant state of confrontation and Sunni Turkey is most likely to join co-religionist Arab Sunni states against Shi'ite Iran. Alliances could be struck along ethnic lines, as well. Arabs and Persians fought bitterly over the long sweep of history, before and after Islam. Turks and Persians, too, fought each other when both were Sunnis, as well as after Persia was converted to Shi'ism by Shah Ismail (1501-1524). Even if the Ayatollahs were removed from power, ethnic conflicts would trigger confrontations among Arabs and Persians, possibly dragging the Turks into the fight. These wars would cost GCC states much of their dollar reserves and the investments of the golden oil century in US Treasury bonds, as well as investments in London's finest real estate properties and grandest hotels.

The political map of the region will most likely change. Iran's occupation since November 30, 1971 (on orders of the Shah) of the three strategically important UAE islands at the mouth of the Strait of Hormuz—Abu Musa, Greater Tunb, and Lesser Tunb foreshadows the shape of things to come. The UAE never accepted Iran's occupation of these islands and continues to demand their return to no avail. In Bahrain, while the majority of Bahrain's population are Shi'ites, the ruling al-Khalifa family is Sunni. For decades, Iran has been calling for the return of Bahrain to Tehran. In 2016, a revolutionary Guard commander close to Iran's Supreme Leader demanded that Iran annex Bahrain. [99] Bahrain's historical background is relevant to mention here. Except for eighty years under Portuguese rule seven centuries ago, Bahrain had been a Persian territory. In 1782, the al-Khalifa clan removed the Persian ruler of the island. Other historical tensions will continue to fester. In Iran, the Arab population of the oil rich Khuzestan province want independence from Tehran. Iraq regards Kuwait as its own 19th province. The Kurds in Iran, Iraq, Syria, and Turkey dream of their own state, and many border disputes engulf GCC member states—Bahrain/Qatar; Kuwait/Saudi Arabia; Oman/Saudi Arabia/UAE; Qatar/Saudi Arabia; and within the UAE; Dubai/Sharjahh.

b) *The Economic Scene*

The transformation from economies dependent on oil revenues to a non-oil based-existence will be painful, although perhaps less so in Dubai. The immediate effect will be felt in the labour markets. Most of the expatriate workers who built and maintain the super modern cities of the GCC, with their glitzy skyscrapers, ice skating rinks, and golf courses would repatriate. While expatriate workers in Saudi Arabia are a third of the population, they provide around three

quarters of the labour force (see footnote 22). In the rest of the GCC, expatriate workers are around 75 percent of their aggregate population and provide around 90 percent of the labour forces. They will leave behind ghost-towns with huge excess capacity airports, desalination plants, roads, schools, hospitals, and public utilities. Without sufficient skilled workers for proper maintenance, the infrastructure would deteriorate quickly in the blazing sun. Compounding the financial stress, real estate values would crash, with millions of empty dwellings and office space.

Over the millennia, scant rainfall and absence of rivers prevented the development of any sizeable settled agricultural communities in the Arabian Peninsula and constrained its capacity to feed more than ten million inhabitants. Today, excluding Yemen, 55 million people live in the GCC alone. They are sustained mainly through food imports and desalinated sea water. After the departure of 25 million expatriates, there will still be tens of millions of local residents. How would they survive? The very rich could afford to move to London's snazzy Knightsbridge, and the less rich would migrate north, to the Levant, repeating what the Bedouin of Arabia have done to survive since the beginning of time. Ultimately, the oil century will give way to the desertification century, eventually restoring the desert to its former pristine condition.

The excesses of the Arabian Peninsula's rulers during the oil century may be described by the fate of one man: "Ozymandias" — the title of Percy Bysshe Shelley poem (1792-1822) about the King of Kings, the mighty pharaoh Ramesses II, whose huge statue and all of his other works are toppled by the sands of time.

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    On Islamic law-making(Shari'a), while Shi'ites observe three sources; Qur'an, Sunna (Shi'ite version), and Shi'ite ulama's intellectual reasoning, Sunni Shari'a sources are four; Qur'an, Sunna, analogical deduction, and consensus of the Sunniulama.
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Biorestauration of Swage Polluted by Waste Motor Oil with *Pleurotus florida* Crude Extract and Mineral Solution

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Abstract- In México, swage is likely contaminated by waste motor oil (WMO) that contains aliphatic and aromatic hydrocarbons. An ecological alternative to solve this problem is bio stimulation with indigenous microbiota to eliminate the aliphatic fraction of WMO. However, this aromatic part of WMO contain benzene recalcitrant, an unexplored alternative is bio stimulation with extract of *Pleurotusflorida (ePf)* and mineral solution for its elimination. The objetive of this research were to analyze bio stimulation swage polluted by WMO containing benzene with *ePf* and mineral solution for its elimination. The effect of bio stimulation of *ePf* plus mineral solution on the WMO and benzene was measuring by the amount of CO_2 produced. This result indicated that bio stimulation of swage polluted by WMO with *Pf* and mineral solution eliminated this fraction to allow the reuse of this water.

Keywords: bioremediation, laccase, water reuse, native heterotrophic microorganisms.

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Abstract- In México, swage is likely contaminated by waste motor oil (WMO) that contains aliphatic and aromatic hydrocarbons. An ecological alternative to solve this problem is bio stimulation with indigenous microbiota to eliminate the aliphatic fraction of WMO. However, this aromatic part of WMO contain benzene recalcitrant, an unexplored alternative is bio stimulation with extract of *Pleurotusflorida (ePf)* and mineral solution for its elimination. The objetive of this research were to analyze bio stimulation swage polluted by WMO containing benzene with *ePf* and mineral solution for its elimination. The effect of bio stimulation of *ePf* plus mineral solution on the WMO and benzene was measuring by the amount of CO_2 produced. This result indicated that bio stimulation of swage polluted by WMO with *Pf* and mineral solution eliminated this fraction to allow the reuse of this water.

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I. Introduction

In Mexico and in many other places, environmental contamination related to petrochemicals has been recognized as one of the most serious problems for wastewater, groundwater, surface water and other bodies of water. In Mexico, the annual production of waste motor oil (WMO) is approximately 325 million liters (Soumeya et al., 2022). It is estimated that only 20% of the volume generated receives adequate final treatment.

The composition of WMO includes a wide range of aliphatic and aromatic hydrocarbons with chain lengths ranging from C 15 to C50, (Iqbal et al., 2018), minor amounts of additives, viscosity improvers, oxidation inhibitors, nitrogen, and sulfur compounds, as well as metals such as lead, zinc, barium and magnesium. These contaminants arise from normal wear of engine components and heating and oxidation of lubricating oil during engine operation. WMO may contain higher percentages of polycyclic aromatic hydrocarbons (PAHs) and additives compared to fresh oil, and the concentration of PAHs in WMO may range from 34 to 190 times higher than those in fresh motor oil (American Public Health Association, 2012; Soumeya *et al*., 2022). Therefore, WMO is a mixture of aliphatic and aromatic hydrocarbons that involves a risk to human health and the environment, notably sewage (Chandra *et al*., 2012).

The presence of benzene in WMO-contaminated sewage is particularly problematic, as it has a relatively high-water solubility (1.8 g/l, 15°C), and is easily transferred to groundwater and drinking water supplies(de Oliveira *et al*., 2009; Mitra and Roy, 2011; Iqbal *et al*., 2018). Benzene is challenging to remove because it lacks an activating (O_2) oxygen or N(nitrogen) substituent group, making the oxidation of the ring not energetically feasible. Long-term health effects of benzene exposure include adverse effects on bone marrow and cancer in humans(El-Naas *et al.*, 2014).

Various biological remediation schemes have been investigated to treat water, sewage, and industrial effluents containing aliphatic hydrocarbons and benzene (Harms *et al*., 2011; Chandra *et al*., 2018). The most widely applied biostimulation for aliphatic hydrocarbon´s its elimination by the native microbial consortium via enrichment withbasic minerals such as nitrogen, phosphorous, potassium, and others (Demir, 2004). However, biological treatment methods have commonly been limited by the toxicity of these compounds, and the correspondingly low concentrations of the substrates to which the microbes must be exposed (Okolafor and Ekhaise, 2022). Yet, while most of the studies have focused on bacteria, little is known about the contribution of fungi of the bioremediation of the environment polluted by benzene (Gadd, 2001; Dittman *et al*., 2002).

Fungal-mediated mineralization of soil pollutants has mainly been assayed with white-rot fungi (Demir, 2004; Okolafor and Ekhaise, 2022). It has been shown that many species belonging to the white rot fungi group can degrade lignin, which is a natural polymer (Harms *et al*., 2011). Therefore, an environmentally friendly solution to induce full or partial mineralization of WMO in sewage is the biostimulation of native microbiota by enrichment with essential macronutrients (Surajudeen and Benjamin, 2009).

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Removal of the aromatic fraction is possible with an extracellular enzyme extract of *P. florida (ePf)*, a basidiomycete that synthesizes Manganese peroxidase (MnP), Lignin peroxidase (LiP) and a Lactase (LiP)(Gadd, 2001; Dittman *et al*., 2002; Demir, 2004; Harms *et al*., 2011). This is an enzymatic complex with a substrate chemical non-specificity to hydrolyze aromatic rings, similar to those in the composition of WMO (Estebar *et al*., 2012). The objetive of this research were to analyze biostimulation swage polluted by WMO containing benzene with *Pf* and mineral solution for its elimination.

II. Material and Methods

a) Fungi cultivation and obtaining of enzymatic crude extract

The fungus *P. florida* was donated by Kamuro Inc. based in Morelia, Michoacán, Mexico. It was grown by preparing malt extract and incubated at 28 °C for seven days. The fungi were inoculated in a flask containing distilled water and 7.5 g of sterile wheat straw as the only source of carbon and energy. The flask was incubated at 28°C for 14 days, according to Demir (2004). At the end of the period, the flask content was centrifuged at 1000 rpm/10 min, and the supernatant was filtered using a Millipore membrane, 0.2 μ. The protein concentration was measured using a curve of bovine albumin as standard. The *ePf* was conserved in glycerol at -20°C until use.

b) Effect of biostimulation with extract of P. florida sewage polluted by waste motor oil containing benzene

WMO was diluted (1:100) in distilled water. Immediately, a sample of 10 ml was transferred to a Bartha flask with 500 ml capacity, with H_2O_2: 2 ppm; $MnSO_4$: 2 mM1.0mland*ePf* 1mg/ml. All Bartha flasks were incubated at 30°C (±2°C), 100 rpm for a three-weeks period. A relative control consisted of 100 ml of sewage with the diluted WMO, with sodium azide, H_2O_2 + MnSO4 and no *ePf* biostimulation. An absolute control composed of 100 ml of sewage, sterilized *ePf*, 10 ml of diluted WMO, Tween 80 and sodium azide was also used to inhibit any biological activity. All assays were carried out using triplicates.

Biostimulation of swage polluted byWMO containing benzene with a mineral solution Six Bartha flasks were used, containing 100 ml of sewage, WMO diluted 1:100, and a mineral solution with the following composition (g/l): K_2HPO_4: 4; $MgSO_4$: 3; NH_4NO_3: 10; $CaCO_3$: 1; KCl: 2; $ZnSO_4$: 0.5; $CuSO_4$: 0.5; $FeSO_4$: 0.2; EDTA 8.0; tween 20 0.01%; H_2O_2: 2 ppm; $MnSO_4$:2 mM;1 and 1 mg/ml of the *ePf* extract. All Bartha flasks were incubated at 30°C (±2°C),100 rpm for another three-weeks period. The experiment was carried out using triplicates (Mathur and Majumder, 2010).

c) Analysis of aliphatic hydrocarbons

The analysis of benzene concentration was carried out using a gas chromatograph (Perkin Elmer Autosystem Series) coupled toa FID, using anElite-5 Capillary Column coated with a 5% diphenyl/95% Dimethyl Polysiloxane stationary phase, 30m length, 0.25diameter, 0.25 mm film thickness in a split injection mode. The carrier gas was Helium; the column oven temperature was 40° C for 8 min and was increased from 40-180° C at 6° C min-1. The injector temperature was 250° C (Gosh *et al.,* 2018).

d) Experimental design

Five treatments, as shown in Table 1, were used to analyze the effect of ePf on benzene ring breakage in sewage with WMO as well as its mineralization by biostimulation with a mineral solution.

Table 1: Experimental essay on biostimulation of swage polluting by waste motor oil *Pleurotusflorida* and biostimulation with mineral solution

Treatment (T)	Sewage	*P. florida* extract	WMO	Sodium Azide	Tween 80	H_2O_2	$MnSO_4$	Mineral solution
1 (relative control)	+	-	+	+	-	+	+	-
2(absolutecontrol)	+	+*	+	+	+	+	+	-
3	+	+	+	+	+	+	+	-
4	+	+	+*	+	+	+	+	-
5	+	+	+	+	+	+	+	+

**Sterilized, (+) =use; (-) = non use*

III. Results

Figure 1 shows that benzene degradation activity was induced by the biostimulation with ePf in sewage contaminated by WMO. The breakdown of WMO benzene showed a delay, that had been mostly degraded; this suggests the presence of the interaction of this aromatic compound interaction between WMO constituents during its degradation. The analysis of WMO yielded an initial benzene concentration of 34.2 μmol in the Bartha flasks. The biostimulation with e*Pf* induced the depletion of benzene concentration in only four days. However, in the same period, there was also an abiotic loss of benzene, probably due to evaporation, since the concentration in the control experiment on the third day was 19.2 μmol. Benzene decreased after four days; in the control treatment without biostimulation with *ePf*, this loss due to evaporation was up to 30% (Figure

1); an abiotic loss of benzene has been reported to increase with incubation time due to its high solubility in water, volatilization and adsorption on the walls of Bartha flasks (Shah, 2017). The aerobic microbial degradation of the WMO had different patterns on CO_2 production(Figure 2).The microbial benzene on WMO breaking increased in 5 days after biostimulation with mineral solution with macronutrients based in mineral salts of N, P, K, and other elements to enriched sewage polluted with WMO; this was followed by a constant decrease over the next 16 days of the issue (Gadd, 2001; Surajudeen and Benjamin, 2009).

While Figure 3 shows the effect of biostimulation of sewage contaminated with WMO by *ePf* and mineral solution on benzene removal that reached up to a concentration of 32.77 μM (according to the data shown in Figure 1) in less than five days compared to the control data, as no further increase in CO_2 production was observed without the biostimulation caused by the mineral solution. The positive effect on CO_2 production rates indicates that the WMO-contaminated sewage contained a sizeable microbial community capable of mineralizing aromatic hydrocarbons.

In figure 4a, shows the chromatogram of benzene before it was broken down by biostimulation with *ePf* in sewage contaminated with WMO diluted 1:100. Figure 4b shows the chromatogram when benzene was eliminated after biostimulation with ePf and mineral solution.

IV. Discussion

This research has been based on biostimulation of the benzene contained in the WMO by *ePf* and its elimination with mineral solution for the indigenous microbial population in sewage polluted WMO (Rajasulochana and Preethy, 2016; Okola for and Ekhaise, 2022). An attempt was made to evaluate the biostimulation by mineralization kinetics of the microbial consortium. The degradation kinetics of WMO benzene, was analyzed and modeled mathematically. This study shows that *ePf* was able to degrade WMO benzene hydrocarbon in a microcosm. These results show that the participation of fungal extract in the biodegradation of aromatic pollutants in sewage is consistent with reports generated by other authors (Demir, 2004; Surajudeen & Benjamin, 2009; Shah, 2017; Chandra et al., 2018). Biostimulation of WMO containing benzene required the *ePf* and mineral solution due to activity of the indigenous microbiota in sewage exhibited the extraordinary capacity of the microbial consortium to mineralize petroleum aromatics hydrocarbons (Dittman et al., 2002; Estebar et al., 2012). These results also confirm that benzene in WMO is more recalcitrant than aliphatic hydrocarbons (Mathur and Majumder, 2010; El-Naas et al., 2014). Currently, bioremediation of WMO-contaminated sewage containing benzene, is carried out through in situ treatments such as bioventing. However, biostimulation of WMO-contaminated sewage with *ePf*and mineral solution are very important to remove aromatic hydrocarbons, including volatilization (Demir, 2004; Surajudeen and Benjamin 2009; Mathur and Majumder, 2010; Mitra and Roy, 2011). Fungi growing on volatile aromatic hydrocarbons have been used successfully for the biofiltration of air containing volatile hydrocarbons (Harms et al., 2011; Iqbal et al., 2018; Okolafor and Ekhaise, 20002).

This preliminary study indicates that biostimulation of benzene-containing WMO-contaminated sewage by *P. florida* extract and mineral solution showed a microbial population capable of mineralizing benzene (Gadd, 2001; Demir, 2004; Chandra et al., 2018). Further studies are still needed to evaluate the biostimulation of benzene-containing WMO-contaminated sewage with *P. florida* extract and mineral solution on a large scale (Rajasulochana and Preethy, 2016).

V. Conclusion

This research concluded that biostimulation of *ePf* ¸ and mineral solution in recovering sewage polluted by WMO containing benzene to reuse in irrigation city gardens and industrial issues.

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Conflicts of interest

The authors declared no have conflict interest for the study.

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Figures

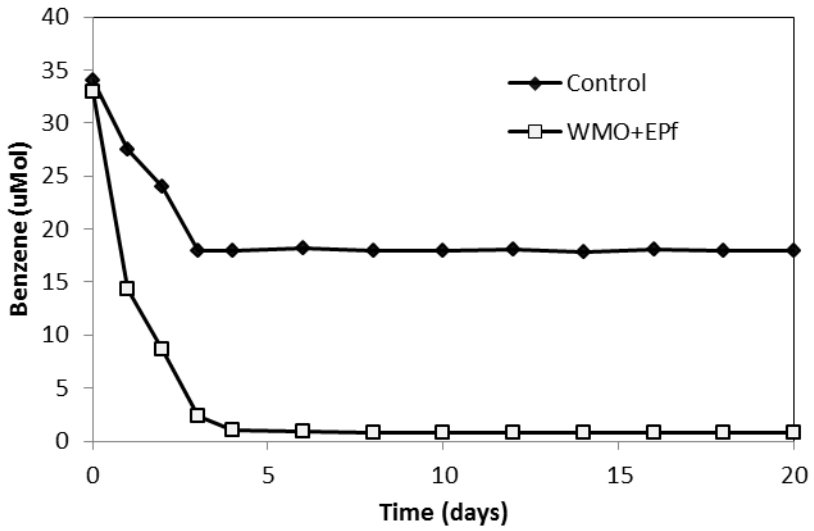

Figure 1: Effect of biostimulation with *Pleurotus florida extract* on benzene hydrolysis in waste motor oil polluting sewage before biostimulation with mineral solution.

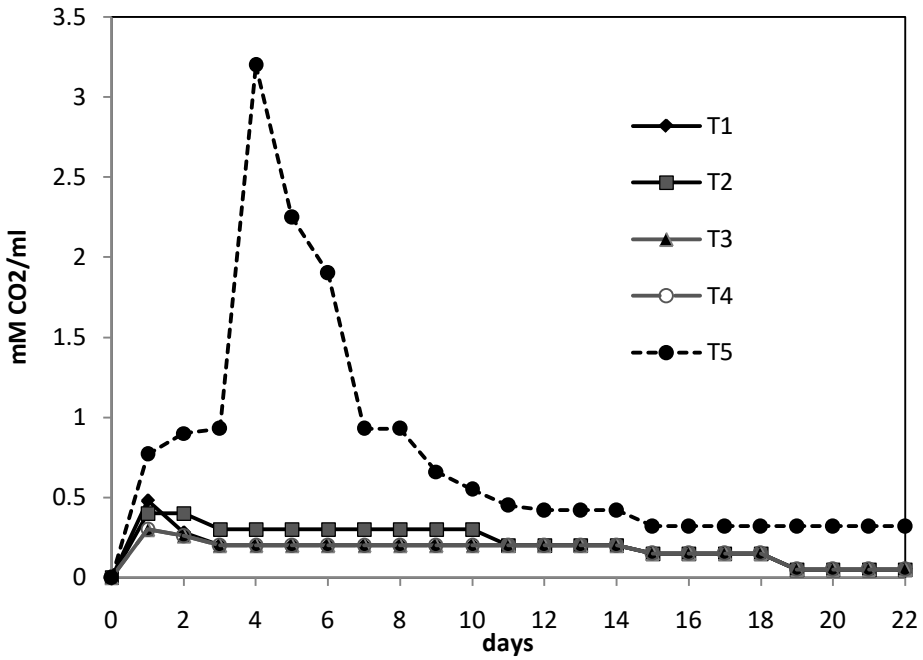

Figure 2: Effect of biostimulation sewage polluted by waste motor oil with *Pleurotus florida* extract and mineral solution

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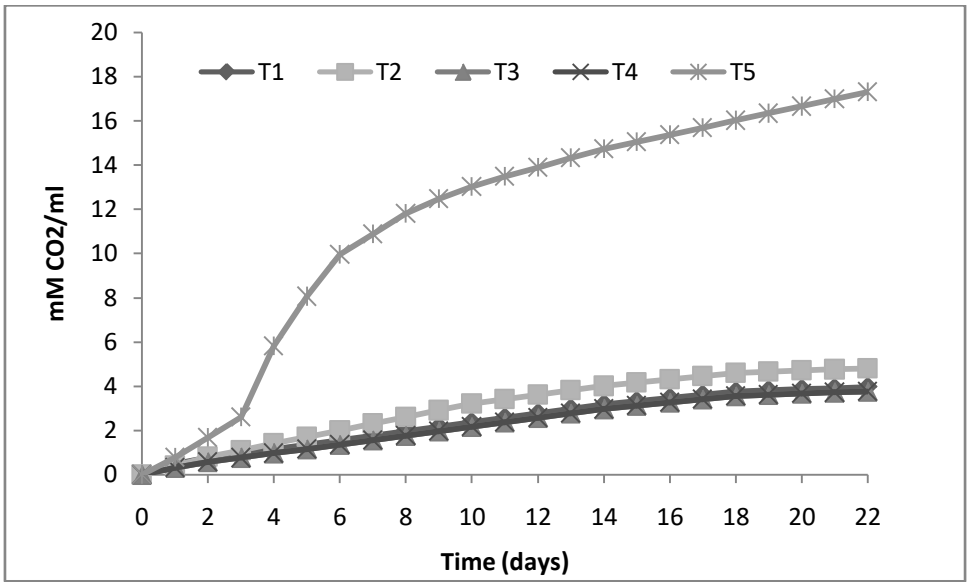

Figure 3: Effect of biostimulation sewage polluted by waste motor oil with *Pleurotus florida* extract and mineral solution on benzene elimination

T1: sewage/WMO (benzene) biostimulated with *P. florida extract* --NaAzide -H_2O_2-$MnSO_4$
T2: sewage/WMO (benzene) biostimulated with Tween 20+ *P. florida extract* +Na Azide+H_2O_2+$MnSO_4$
T3: sewage/WMO (benzene) biostimulated with Tween 20 - *P. florida extract* +Na Azide+H_2O_2+$MnSO_4$
T4: sewage/WMO (benzene) biostimulated with tween 20+ *P. florida extract* sterilized+ Na Azide +H_2O_2+$MnSO_4$
T5: sewage/WMO (benzene) biostimulated with tween 20+ *P.florida extract*+H_2O_2+$MnSO_4$+mineral solution

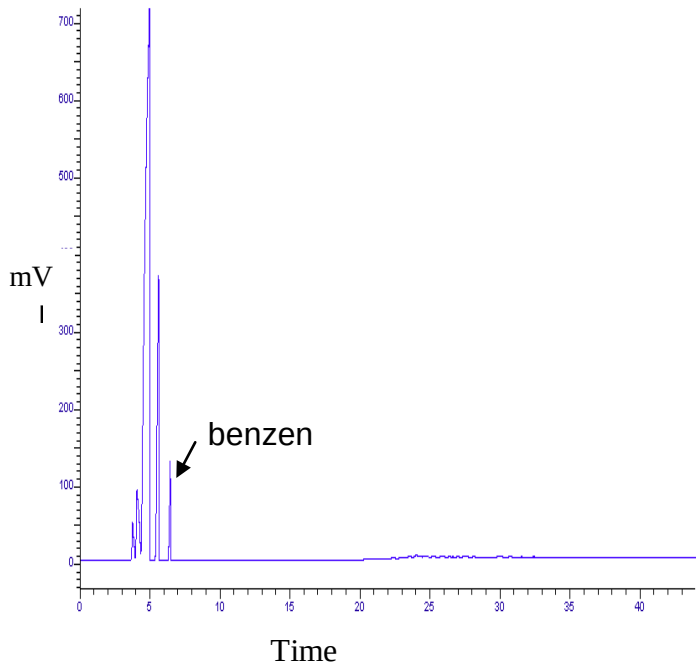

Figure 4a: Chromatogram showing the benzene peak before been breaking by *ePf* insewage sludge polluted with waste motor oil

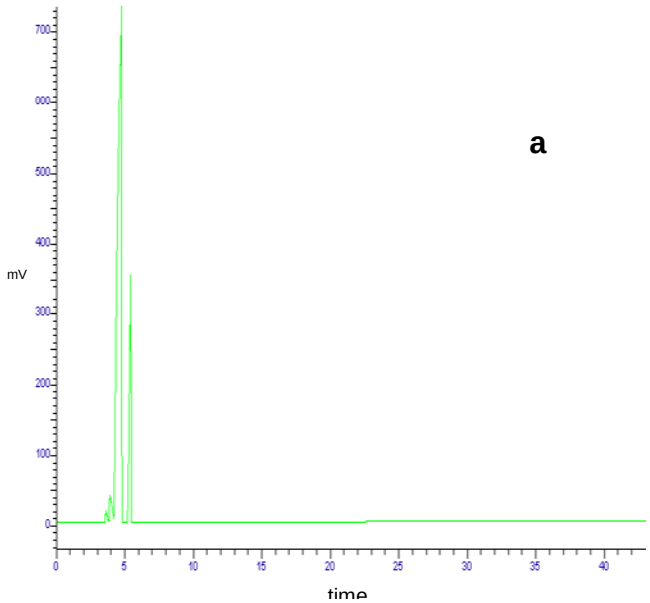

Figure 4b: Chromatogram showed when benzene in waste motor oil was mineralized completely after applying e*Pf* polluted with sewage

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Toxic Metals through the Prism of World Warfares

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Abstract- The study of effects from environmental pollution by toxic substances due to warfare is not a new subject, although it remains poorly explored in many criteria. More and more scientific data shows that armed conflicts and military actions significantly contribute to pollution of the environment with toxic substances, and heavy metals in particular. Lately, Ukraine has been facing that problem in acute form.

The aim of the study is to provide an analytical overview of the current state of environmental pollution by toxic metals and organic substances released due to the armed conflicts, exercises and protracted wars in the world and to show the possible risks for the human health and for the environment.

Keywords: *toxic metals, warfare, environment, hazards for humans.*

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Toxic Metals through the Prism of World Warfares

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The aim of the study is to provide an analytical overview of the current state of environmental pollution by toxic metals and organic substances released due to the armed conflicts, exercises and protracted wars in the world and to show the possible risks for the human health and for the environment.

Significant accumulation of metals was observed in the battle fields, small arms shooting ranges, artillery, mortar and jetranges, as well as grenade launching grounds during exercises. Weaponry residue left in the fields during warfare, combustion products from ballistic missiles and products of destroyed infrastructure (metallurgical combines, oil depots etc.) pose a threat due to their long-term impact on the current and descendant population. Metal emissions linked to military actions can play a significant role in the health hazard of both civillian population and military personnel that live in the area affected by pollution. Military action leads to soil pollution with Pb, Cu and other metals, that include Cd, Sb, Cr, Ni, Zn with their further leaching into groundwater, resulting in the increased risk of human exposure, as a consequence.

More than ever, today Ukraine needs legislative regulations of this impact on the environment and the population of the country, improvement on systems of monitoring and biomonitoring for pollution and assessment of risks for the impact of toxic substances on the environment and humans.

Keywords: toxic metals, warfare, environment, hazards for humans.

I. Introduction

Population growth all over the World and huge production of wastes contribute to the aggravation of environmental problems and climate change. Of all human activities, war has the worst impact on the environment: on the one hand, hostilities have a negative impact on human health, and on the other hand, war resources could be better spent for the nature preservation and development of new safety technologies.The last 30 years have been marked by the emergence of local military conflicts, such as the military attacks in Iraq (1990-1991), the Israeli operations in Palestine (2008-2009), the war in Yugoslavia (1991-2001), Afghanistan (1979-1989, 2001-2022), the war in Syria (2012-2021)and Georgia (August 2008). New is the situation that has been taking place in Ukraine in recent years (operation OOS-2014-2022, and the active phase of the war, which begins on February 24, 2022). Evidently, the armed conflict and military activities pollute significantly the atmosphere with toxic substances. Along with emission of organic pollutants including polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), as well as hexa chlorocyclohexane (HCH), dichlorodiphenyltrichloroe-thane(DDT), and hexachlorobenzene (HCB), military activity is associated with environment contamination by chromium, copper, zinc, lead, and cadmium to name a few (Hopke, 2009, A. Skalny et al, 2012,2021).

During an explosion, all substances undergo complete oxidation, and the products of the chemical reaction are released into the atmosphere. The main ones - carbon dioxide and water vapor - are not toxic, but harmful in the context of climate change, as both are greenhouse gases (Wingfors et al., 2014; Aurell et al., 2019). In the atmosphere, oxides of sulfur and nitrogen can cause acid rain, which changes soil pH and causes burns. Acid rain is known to have a negative impacton the human body and other mammals and birds, affecting the condition of mucous membranes and respiratory organs.

In Ukraine, there were numerous recent cases when ballistic missileshit the tank farms. Explosions leaded to the emission of number of toxic gases and solid particles (IFs) into the atmosphere. Significant soil and watercontamination is also possibleand around these areas. It should be noted that petroleum products have additional side effects. Their hydrocarbons are able to interact with a number of other environmental pollutants, such as pesticides, toxic metals, which together with petroleum products are concentrated in the near-surface layer of soils and water bodies.

Metal fragments of shells produced by military activity also pollute environment. They contain sulfur and copper, and a number of other toxic metals.Metallised incendiary mixtures, which include petroleum products with the addition of magnesium or aluminium shavings, oxidizers, liquid asphalt and heavy oils are used to equip tanks, mechanised and knapsack flamethrowers, aircraft

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bombs, as well as fire explosives of various types, can also be additional sources of pollution.

In addition, it has been shown that metal emissions depend on the type of ammunition. Specifically, firing with NM229 containing a steel core results in significant emission of Cu and Zn, whereas SS109 with soft lead core produces high number of Pb particles (Mariussen et al., 2021).In turn, firing lead-free small-caliber ammunition results in a significant emission of particulate matter consisting predominantly of Cu, Zn, and Fe, as well as soot originating from incomplete combustion (Wingfors et al., 2014).The content of Pb, Cu, Ni and Zn was found to be related to specific substances in air, with size of 1.95 μm, 0.01 μm, 1.22μm, 8.10 μm, respectively (Orru et al., 2018). In addition, the emissions of metals due to the application of firearms are is very different for pistols, rifles and shotguns. Therefore,the analyze of the air composition is needed to detect the content of metal nanoparticles (Charles et al.,2020). There is every reason to believe that much of the particles may easily penetrates the alveolar region of the lungs due to their size distribution. Some of them, which are considered more toxic to humans - are the endocrine disruptors.

In general, according to our information search, the number of toxicologically and hygienically important chemicals and their metabolites to be determined reaches at least a few hundred. Given the duration of hostilities in Ukraine, it would be important to assess the possible pollution effects of modern weapons.

The aim of the study is to provide an analytical overview of the current state of environmental pollution by toxic metals and organic substances released due to the armed conflicts, exercises and protracted wars in the world and to show the possible risks for human health and for the environment.

a) *Weapon residues as sources of metal emission- the impact of weapons remnants and emissions on the environment*

Specifically, significant accumulation of metals has been observed in areas of battle fields, small-arm shooting ranges, artillery, mortar and rocket ranges, and grenade courts (Barker et al., 2021). Military-related metal emissions with their potential subsequent overexposures may therefore play a significant role in health hazards to military personnel (Kalinich and Kasper, 2016).

Environmental monitoring studies demonstrated significant soil contamination resulting from military activities (Broomandi et al., 2020). Specifically, analysis of soils from military shooting ranges demonstrated significant contamination with Pb, Cu, Cd, Sb, Cr, Ni, and Zn (Etim and Onianwa, 2012; Islam et al., 2016). Consistent with these observations, a meta-assessment of soil metal levels revealed a significant increase in soil Pb, Cu, Hg, Sb, Ni, and Cr content in different shooting ranges, whereas elevated soil Pb could be considered as the most significant health hazard (Bai and Zhao, 2020). Moreover, Pb bioavailability from army shooting range soils was found to be 42% thus possessing significant hazards for biota (Islam et al., 2016). In contrast to Pb, soil Cr and Ni levels were found to be slightly affected by shooting activity (Etim and Onianwa, 2012).In another study demonstrated that soil mercury (Hg) content in the area of active gun use was nearly 10-fold higher as compared to the reference soils (Gębka et al., 2016). Similarly, an indoor firing range dust analysis revealed high levels of Pb and Cu, but the increase in Ni, Cd, Cr and Zn content was moderate-to-significant (Clarke et al., 2020). It is also noteworthy that other military facilities are characterized by soil metal pollution along with shooting ranges. In particular, soil Cd and Pb levels were found to be significantly increased at a former military airport, with the highest levels in the proximity of fuel bunkers (Skalny 2021).

Emission of metals into the environment upon military activity occurs from gunshot residues containing high levels of metal-containing particles (Charles et al., 2020), as well as from use of artillery, grenades, and rockets (Barker et al., 2021). An earlier study demonstrated various sources of metals in gunshot residues including primers (lead (Pb), antimony (Sb), barium (Ba)), metal jacket bullets (Cu, Zn), and gun barrels (Fe) (Brazeau and Wong, 1997). In indoor shooting ranges, Pb, Cu, Ni and Zn contents were found to be associated with different fractions of airborne particular matter, namely 1.95 μm, 0.01 μm, 1.22 μm, 8.10 μm, respectively (Orru et al., 2018). In addition, emission of metals with gunshot residues were shown to be quite different for pistols, shotguns, and rifles (Bailey et al., 2009), thus being indicative of the usefulness of gunshot residue analysis in forensic science (Charles et al., 2020).

In war areas people are exposed to it via contaminated air, food and water, due to the modern weaponry and absorption in the soil. The hexavalent chromium can cause various health effects, ranging from rashes, allergic reactions and respiratory problems to immune system impairments, organ damages and cancers (Sharma et al., 2012). Adverse impact of war is not limited to those who experience it directly, but is passed on to future generations through multiple mechanisms. International organizations are obliged to protect parents and infants from the modern weaponry in wars(M.Vänskäa, S.Y. Diabb 2019).

Metal emissions were shown to be dependent on the type of ammunition. Specifically, firing with NM229 containing a steel core results in significant emission of Cu and Zn, whereas SS109 with soft lead core produces high number of Pb particles (Mariussen et al., 2021). In turn, firing lead-free small-caliber ammunition results in a significant emission of particulate matter consisting predominantly of Cu, Zn,

and Fe, as well as soot originating from incomplete combustion (Wingfors et al., 2014). Explosives also play a significant role in metal emissions into environment. Particles emitted from artillery backblasts were found to contain high levels of Pb and Cu that may originate from artillery shells, gun barrels, or deposited dust (Gillies et al., 2007). Flash bang grenades were also considered as a significant source of high concentrations of Pb (Weber et al., 2020).Depleted uranium (DU) has been used in widely used in military industry and especially projectile production. Correspondingly, DU-containing penetrators were shown to release DU particles during abrasion, combustion, and corrosion was reported in the review(Skalnyet al., 2021)

Thus, one can speak not only about the complex pollution of air, soil and water, but also, what is important, about the exposure of metals in the form of nanoparticles. As you know, nanoparticles penetrate into the lungs with inhaled air faster and better penetrate into the blood, that is, even small doses can act as strong toxicants.

b) Metal exposure in humans involved in military activity

Embedded fragments resulting from shrapnel wounds possess a significantsource of metal exposure in military personnel and retiredveterans, although the particular patterns of metal accumulation arestrongly dependent on metal contents of the ammunition. A detailedanalysis of the embedded components in injured military personneldemonstrated that the most common metal constituents were Fe, Cu,and Al, whereas Pb, Sb, Ti, and U were detected at trace levels (Centeno et al., 2014).

Exposure to other metals originating from military activity was alsoshown to result in a broad spectrum of adverse health effects. Specifically,it has been demonstrated that metal constituents of PM2.5 namelyNi and vanadium (V) are considered as survival predictors in a cohort ofU.S. military veterans (Lipfert et al., 2006). Military personnel with retained fragments after battlefield injury are also characterized byimpaired immune function characterized by increased lymphocytestimulation index, elevated IgE levels in parallel with a decrease in IgA,IgG, IgM levels (Samelko et al., 2020). Metal exposure may also underlie increased risk of amyotrophic lateral sclerosis (McKay et al., 2021) andototoxicity (Hammill et al., 2019) in military personnel. Finally, it is hypothesized that toxic metal accumulation may induce antimicrobial resistance in *Acinetobacter baumannii*(Bazzi et al., 2020)Legionnaires' disease, which is associated not only with bacterial exposure, but also with increased levels of Co in the body (Gold, 2007).

In 2003, the Norwegian armed forces changed their primary assault rifle to the HK416 (Heckler & Koch, Germany). Shortly after the new weapon was put into service, flu like symptoms after training sessions at firing ranges were reported. It became evident that the symptoms were due to exposure to gunshot fumes. The symptoms were similar to what previously have been observed among welders. The symptoms were attributed to the newly introduced ammunition with a steel core instead of a lead (Pb) core, and further use of this ammunition type was temporarily prohibited (Mariussen, 2021).

The rationale for replacing the traditional lead core bullets with the steel core bullets by the Norwegian armed forces in 2003, was to reduce both the environmental load of Pb contamination and the shooters exposure to Pb. Several studies have shown that exposure to Pb during training increases the level of Pb in the blood. In addition to exposure from training at firing ranges, there are also raised concerns about long-term effects of Pb exposure from consumption of game (Mariussen et al.,2021).

In a study by Voie et al. (2014), volunteers were exposed to gunshot fumes from the two ammunition types with steel core, NM229 and NM255, in addition to the leaded SS109 in order to compare health effects induced by gunshot firing. The main findings showed that all three ammunition types induced temporarily, but prominent health effects such as fever, coughing, increased C-reactive protein (CRP) in blood and reduced lung function, similar to the symptoms from metal fever. In addition, carbon monoxide (CO) in the fumes led to increased levels of carboxy hemoglobin in the blood of the exposed shooters. CO-poisoning may lead to headaches and seriously decrease judgment and performance (Mariussen, et al., 2021).

Along with military personnel, trainees, shooting range shooters, as well as civilian subjects living on the living in territories of armed conflicts or near military training grounds could be considered at high risk of military-related metal exposure.(Skalny et al.,2021).

c) Possible negative consequences and risks for public health

Exposure to toxic metals have been shown to cause adverse health effects associated with cardiovascular, metabolic, neurological and kidney disease, as well as cancer (Skalny et al., 2021).

A number of studies demonstrated the potential contribution of metal overload to adverse health effects in children living on the territories affected by military activity. In particular, military attacks were found to be associated with in utero metal exposure with the most prominent increase in As, Ba, and molybdenum (Mo), that could be potentially linked to underweight and stunting in children (Baraquoni et al., 2020). Moreover, a recent study demonstrated increased exposure of women to weapon-related heavy metals including Ba, As, Co, Cd, Cr, V and U in Gaza District (Palestine) that is associated with the number of preterm births and

higher prevalence of birth defects (Manduca et al., 2020).

Military attacks are a source of heavy metal exposure among people living in war zones, as various heavy metals are used in new generation weapons. As an example, the waste of nuclear industry is re-used in depleted uranium weapons, which poses both radiological and chemical toxicity in humans (Hon, Österreicher, & Navrátil, 2015; Ifesinachi, 2014). In addition, weapons can be "enhanced" by the utilization of heavy metals as augmenters or as primary effective agents, and some new weapons are able to produce a 'molecular sieve' of toxic metal powder that can severely affect the human body. Analyses of wound tissues of war injuries provide evidence of civilian contamination to metals with toxicant, teratogen and carcinogen effects on human body (Skaik et al., 2010). Importantly, in addition to the risks posed by acute exposure, the persistence of heavy metals in post war environments can cause prolonged exposure, leading to accumulation of metals in compartments of the body (M. Vänskäa, S.Y. Diabb 2019).

Women and children are highly vulnerable during periods of war and military attacks, as well as in the aftermath of war, because of the possibility of the longterm effects of war related environmental changes on reproductive and infant health. Accumulation in human bodies of toxicants and heavy metal teratogens found in the remnants of war occurs, that, coupled with their long persistence in the environment, suggests a considerable risk for health. The effects of toxicants, teratogens and carcinogens related to heavy metals have been found in embryos at concentrations lower than in adults. During the first trimester of pregnancy, major morphogenetic events occur, and is the period of highest sensitivity of the embryo to external effectors. Apart from the mutational risks posed by some of the heavy metals, there is compelling evidence of their prevalent epigenetic mechanisms of action.(Ivanicoli et al 2009). Heavy metals act as endocrine disruptors, and their interference with gene expression causes disturbances in various metabolic and hormonal pathways (Manduca et al.,2017).

The prevalence of birth defects increased in areas heavilyexposed to military attacks in Iraq, and in Gaza afterthe Israeli military operation of Cast Lead in 2008–2009and since the implementation of air delivered weaponsin attacks. Previous research in Gaza also showed thatwomen's exposure to military attacks (courtesy of thedatabase of the United Nations' mine action team)correlated with a higher incidence of progeny with birth defects(Alaani S,2012; Abed Y,2014).We found a positive correlation between a high load of toxicants (Ba,Al, V, Sr and Cr), a teratogen (W) and a carcinogen (As)in women's hair and their proximity to military attacks in 2014. We also found that there was a higher load in the entire cross sectional convenience sample of Gaza women in comparison with the hair samples from individuals in areas unaffected by war (RHS), regardless of their recent exposure to attacks. The high load was for heavy metalsal ready detected as war remnants from previous attacks in2009 (toxicants such as Al, Fe, Ba, Mn, Cr, Ni, Pb, Sr and V; teratogens such as U and W; and carcinogens such as As, Cd and Co).(Manduca et al., 2017)

The heavy metal load in newborns was higher than that of normal newborn babies for teratogens (mercury and selenium) in babies with birth defects and for toxicants (barium and tin) in premature babies. Together, the data show an association of the damage to newborn health with maternal exposure to attacks, and the trans-placental passage of wartime heavy metal remnants from exposed mothers to their progeny in utero (Naim A,2012; 2013).

The participants were 502 palestinian mothers, pregnant in their first trimester during the 2014 War on Gaza. The mothers were recruited at their delivery (T1) and followed at the infants' age of 6–7 months (T2; N=392). The load of five weapon-related heavy metals (chromium, mercury, vanadium, strontium, and uranium) was analysed by Inductively Coupled Plasma Mass Spectrometry (ICP/MS) from mothers' hair samples at childbirth. In the whole sample and ineach subgroup, the load of toxicants (Al, Fe, Ba, Mn, Ni, Pb, Sr and V), teratogens (Hg, U and W), carcinogens (As,Cd and Co), and of Mg and Zn was significantly higher in the hair of women in all groups of the Gazacross sectional convenience sample than in the reference group. The load of Cs, Cu, Mo, SE, Sn and Ti did not significantly differ from what was found in the reference group.

Besides the identification of a high load of heavy metals, which we specifically traced to exposure to the military attacks in 2014, we found that all the participants had levels significantly higher than controls from outside are as affected by war (RHS) of other war remnant heavy metals, such as U, Hg, Cd, Co, Fe, Ni, Pb, V, Mn, Cd andCo. Previous reports had shown their delivery in Gaza by weaponry; teratogens Hg and Cd and toxicants Pb andFe were delivered by weapons in the 2008–2009 war.Ahigh load of Hg was reported in newborns of mothers exposed at that time to bombing and to attacks with white phosphorus ammunitions (Alaani S, 2011; Abed, 2014; Naim A, 2013, 2012) High loads of Al, Fe, Cd, Hg and U were detected in the hair of children tested 1 year after the 2008–2009 attacks (Manduca et al. 2017).

d) Toxicity of weapon emissions in model studies

The gunshot fumes consist of complicated mixtures of PM, gases, and aerosols of different chemical origin. The PM contains metals orginating from the bullet and the primer, such as Zn, Cu, Pb and iron (Fe). There will be formed combustion products from the gunpowder, such as soot and trace amounts of poly

aromatic hydrocarbons (PAHs), in addition to gases such as CO, CO_2, H_2O, CO, HCN, NH_3, NOx, SO_2 and HCl (Wingfors et al., 2014; Aurell et al., 2019). It has been shown that more than 90% of the total amount of particles produced have diameters less than 30 nm (Wingfors et al., 2014; Aurell et al., 2019). A major concern is if repeated exposure to gunshot fumes may lead to harmful effects in the long term. These effects may include chronic pulmonary effects and even cancer, which may be induced by DNA-toxic substances such as PAHs. A study by Palmer et al. (1994) showed that emissions from the M16 rifle were mutagenic in the Salmonella/Ames test. The effect was associated with the nanosized particles. (Mariussen et al., 2021).

The cytotoxic effect of the smoke was tested to compare the general toxicity of the different ammunition types (from thethree ammunitions, NM255, NM229 and SS109). The generated gunshot fumes were subjected to physical and chemical characterization with respect to particle mass- and number-size distribution. Collected PM were analysed for Cu, Zn and Pb. In addition, the gasses CO2, CO, NH3, HCN and NOx. were measured by Fourier transform infrared spectroscopy (FTIR) (Mariussen et al., ,2021). Genotoxicity was elucidated by the comet assay, which is a widely used method to detect DNA breaks *in vitro* as well as *in vivo* (Collins et al., 2008). A modified version of the comet assay using the lesion-specific enzyme form amidopyrimidine DNA glycosylase (Fpg) was used to detect oxidized purines, which is an indicator of oxidative stress induced DNA lesions (Collins et al., 1996).

In conclusion, the emitted fumes from gunshots consist of complicatedmixtures of PM and gases, which can be harmful to exposedpersonnel. Most of the generated PM has, on a number basis, a sizedistribution of less than 100 nm. The smallest particles will rapidlyagglomerate into larger particles, but even several minutes after thefiring, there is reason to believe that a substantial portion of the particleshave a size distribution that will easily penetrate into the alveolar regionof the lungs. The use of the ALI approach is a promising tool to addressmore realistically potentially toxic effects on the lungs (Upadhyay and Palmberg, 2018). This experiment indicates that the gunshot fumes arecytotoxic to lung cells, and at high concentrations may induce genotoxity.The effects on the lung cells were related to the generated particlesfrom. As an additive to metals and gases, which are less likely to occur in this experiment, fire fumes can also be controlled by soot and trace PAHs (Wingfors et al., 2014; Aurell et al., 2019), which can contribute to toxicity (Mariussen et al., 2021).

War in the Balkans has prompted the investigation and use of other materials including heavymetal tungsten alloys (HMTAs) as nontoxic alternatives. Interest in the health effects of HMTAs has peakedsince the recent discovery that rats intramuscularly implanted with pellets containing 91.1% tungsten/6%nickel/2.9% cobalt rapidly developed aggressive metastatic tumors at the implantation site. Discovery of the superior mechanical properties obtained from the W–Ni–Co and W–Ni–Fe alloy systems has led to their recent use and development for fragmentation warheads and kinetic energy penetrators for defeating heavy armor (Gold et al., 2007; van der Voet et al., 2007).The in vivo carcinogenic potential of HMTAs containing W, Ni, and Co is supported by in vitro studies which demonstrated that exposure to military-relevant mixtures of W, Ni, and Co (WNiCo) induced malignant transformation, generation of reactive oxygen species (ROS), oxidative DNA damage, and expression of several stress genes in various cultured cell types, suggesting a synergistic effect that exceeded the effects of the metals individually (Harris et al., 2011; Miller et al., 2002, 2004). Although military-relevant mixtures of W, Ni, and Fe (WNiFe) also induced genotoxic effects and induced cell transformation in vitro (Miller et al., 2001), other studies found that WNiFe was less toxic than WNiCo and did not induce tumors in rats (Harris et al., 2011;Kalinich et al., 2005).

In another study shows (Roedel et al, 2012) that the intratrachealinstillation of WNiCo and WNiFe causes lung's rat injury by inducing pulmonary inflammation and the generation of toxic oxygen radicals. We propose that the rapid intracellular ROS/RNS formation inducedby WNiCo, and to a lesser extent,WNiFe,may also lead to a gradual depletionof energy stores and subsequent diminished oxidative burst response and phagocytosis capability of lung macrophages, there by compromising their defensive role. The *in vivo* carcinogenic potential of HMTAs containing W, Ni, and Co is supported by in vitro studies which demonstrated that exposure to military-relevant mixtures of W, Ni, and Co (WNiCo) induced malignant transformation, generation of reactive oxygen species (ROS), oxidative DNA damage, and expression of several stress genes in various cultured cell types, suggesting a synergistic effect that exceeded the effects of the metals individually (Harris et al., 2011; Miller et al., 2002, 2004). Although military-relevant mixtures of W, Ni, and Fe (WNiFe) also induced genotoxic effects and induced cell transformation in vitro (Miller et al., 2001), other studies found that WNiFe was less toxic than WNiCo and did not induce tumors in rats (Harris et al., 2011; Kalinich et al., 2005; Roedel, 2019).

By the way in the same study(Roedel,2019) were used military-relevant metal powder mixtures consisting of 92% tungsten/5% nickel/3% cobalt (WNiCo) and92% tungsten/5% nickel/3% iron (WNiFe), pure metals, or vehicle (saline) were instilled intratracheally in rats.Pulmonary toxicity was assessed by cytologic analysis, lactate dehydrogenase activity, albumin content, andinflammatory cytokine levels in bronchoalveolar lavage fluid 24 h after instillation. The

expression of 84stress and toxicity-related genes was profiled in lung tissue and bronchoalveolar lavage cells using realtimequantitative PCR arrays, and in vitro assays were performed to measure the oxidative burst responseand phagocytosis by lung macrophages. Results from this study determined that exposure to WNiCo andWNiFe induces pulmonary inflammation and altered expression of genes associated with oxidative andmetabolic stress and toxicity (Roedel et al, 2012). Inhalation exposure to both HMTAs likely causes lung injury by inducingmacrophage activation, neutrophilia, and the generation of toxic oxygen radicals macrophage activation, neutrophilia, and the generation of toxic oxygen radicalscompromising their defensive role.

Result of this study determined that the intratrachealinstillation of WNiCo and WNiFe causes lung injury by inducingpulmonary inflammation and the generation of toxic oxygen radicals (Roedel et al, 2012).We propose that the rapid intracellular ROS/RNS formation inducedby WNiCo, and to a lesser extent, WNiFe, may also lead to a gradual depletionof energy stores and subsequent diminished oxidative burst responseand phagocytosis capability of lung macrophages, thereby.The obtained results emphasize thatinvestigation of additional metal combinations used in HMTA development is warranted.

However, there is a large difference between the concentrations required to achieve an in vitro effect compared to real-life exposure, which is a problem in risk assessment (Ryu et al 2007, Lipfert F. W. (2017). Developing an acceptable in vitro methodology that can more accurately mimic chronic exposure, for example through more sensitive endpoints, will reduce this gap in the future.

II. Conclutions

Measures developed for the prevention of overexposure ~~of~~ to military-related metals should include legislative regulation concerning impact of military activities on the environment, rehabilitation of metal-contaminated surroundings, improvement of the pollution monitoring and biomonitoring, assessment of the risks on human health related to the exposure to toxic elements.

In particular, the toxic effects depend on a variety of factors, including armortype, chemical constituents of the ammunition, routes of exposure, environment characteristics, to name a few. Moreover, combined metalexposure that occurs due to the use of alloys may potentiate metal induced toxicity. Interactive effects of toxic metal and persistent organic pollutant exposure should be also taken into account.

It is hypothesized that due to the accumulation of metals in the organism, the increased metal body burden may mediate latent and persistent health effects, some of which may not be unmasked for decades after exposure. However, estimation of the particular contribution of metal toxicity may be limited due to a variety of hazardous factors persisting during military activities and especially armed conflicts.

Therefore, monitoring programs are needed for further epidemiological, biomonitoring and laboratory studies to identify the impact of military metals (including their nanoforms) and to establish the main mechanisms of their adverse toxic effects.

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Presence of Arsenic in Argentinian Rices. Strategies to Minimize Them

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Abstract- Arsenic (As) is a ubiquitous chemical element present in nature that is harmful to live beings; it has been classified as a carcinogen class 1, and its toxicity depends on its chemical form, resulting in the inorganic forms being more toxic than organic forms. It is known that rice is one of major contributors to the consumption of inorganic As for humans. Because of this, the Codex Alimentarius defined as maximum values of total As and inorganic As in polished rice of 0.30 mg kg^{-1} and 0.20 mg kg^{-1}, respectively. Rice is efficient in absorb high amounts of As because anaerobic condition generated from flood increase As availability and mobility. Natural resources used for rice production (soil and water) in Entre Ríos province of Argentina are characterized by low total contents of As, while in white polished rice grains mean value is 0.34 mg total As kg^{-1}.

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Presence of Arsenic in Argentinian Rices. Strategies to Minimize Them

María Romina Befani [α], César E. Quintero [σ], Joaquín. Panozzo [ρ], María de los Angeles Zamero [Ω], Luis Risso [¥] & Juan Pablo Hernández [§]

Abstract- Arsenic (As) is a ubiquitous chemical element present in nature that is harmful to live beings; it has been classified as a carcinogen class 1, and its toxicity depends on its chemical form, resulting in the inorganic forms being more toxic than organic forms. It is known that rice is one of major contributors to the consumption of inorganic As for humans. Because of this, the Codex Alimentarius defined as maximum values of total As and inorganic As in polished rice of 0.30 mg kg^{-1} and 0.20 mg kg^{-1}, respectively. Rice is efficient in absorb high amounts of As because anaerobic condition generated from flood increase As availability and mobility. Natural resources used for rice production (soil and water) in Entre Ríos province of Argentina are characterized by low total contents of As, while in white polished rice grains mean value is 0.34 mg total As kg^{-1}.

The addition of phosphate fertilizer, in many cases, depresses rice yields despite the low availability of soil P, which would be explained by the release of natural As to soil solution. Thus, field studies were conducted to evaluate the effect of fertilization and management on the yield of rice and grain As accumulation.

The effect of irrigation was evaluated, oxygenating the soil during the vegetative period, which allowed reduces the level of total As in grains, without any loss of yield. A second study considered the effect of phosphate and zinc fertilization. As was also added to test a greater availability of this element in soil.

The concentration of P and Zn in grain was not affected by the treatments. Under natural conditions of low availability of As, P and Zn fertilization did not improve yield or affect the absorption of As for rice crop. While, with the high availability of As, the yield was severely affected but the combined addition of P and Zn allowed to mitigate its toxic effect. These results are crucial to understanding the dynamics of As in the soil-plant system under field conditions and to developing practical management recommendations.

I. Introduction

Rice is one of the main contributors to the consumption of inorganic As in humans. That is important in the communities that include a high amount of rice in their diet. As has been classified as a carcinogen class 1 and its toxicity depends on its chemical form. Inorganic As is highly toxic, and the specie pentavalent (V) is more harmful than trivalent (III). The Codex Alimentarius established maximum values of total As and inorganic As in polished rice of 0.3 mg kg^{-1} and 0.2 mg kg^{-1}, respectively (WHO, 2012; WHO, 2019). On the other hand, current analytical techniques permit quantifying accurately and quickly the concentration of As in rice grain for a more precice diagnosis.

Globally, depending on the constitution of the original material, the contents of total As in uncontaminated soils vary from 0.1 to 40 mg kg^{-1} with an average value of 3-4 mg kg^{-1}. Considering the toxic effects, in agricultural soils has been established a maximum guideline values of total As between 10 and 50 mg kg^{-1}.In soils contaminated with As, have been documented concentrations of this element in rice grain that exceed the limit established by the Codex Alimentarius (Khan, et al., 2010) but there are also situations of non-contaminated soil, where levels of As in grain may exceed the maximum allowed (Norton, et al., 2012).

Although in rice production areas of Argentina values of total As in soils are in the range of 1.4 to 5.6 mg kg^{-1}, has been detected levels of total As in polished rice grains that exceed 0.3 mg kg^{-1}. A favorable aspect is that rice grown in Entre Rios dominates by organic species (dimethylarsinic acid) and inorganic form is in a low ratio without exceeding the limit value of 0.2 mg kg^{-1} (Quintero, et al., 2014; Oteiza, et al. 2020).

Possible agronomic management practices to reduce absorption and accumulation of As in rice grain are: 1) selection of varieties with reduced absorption and translocation of As to grain (Norton, et al., 2012);2) irrigation management that allowing oxidation of soil in some period of cultive to reduce elution of As, 3) facilitate the formation of poorly soluble compounds by adding Fe or Zn (Das,. 2007), 4) inhibit or reduce the absorption of As by roots adding silicates (Si) that compete with the transporters cell wall and 5) minimice phosphate fertilization. The P would favor the release of chemisorbed arsenate and also this element is re-mobilized from the stems to grains with the same transporters that are used for As. When there is low availability of P, the plant gives priority to the transport of P to the grain over As (Zao, et al 2009).

Considering this background, two field trials were performed in order to establish agronomic practices to reduce concentration of As in the rice grain. The aim of this study was to evaluate the effect of irrigation management and fertilization on the yield of rice and grains As accumulation.

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II. Materials and Methods

a) Experiment 1

During the 2012/13 and 2013/14 seasons, in the localities of Santa María and San Ramon, province of Entre Rios, Argentina, three field studies was conducted in a split-plot design within the farm field, with three replications. Soils in the sites studied are classified as Vertisols. The main plot was divided by water management in: i) continuous flood irrigation (RC) from the state of 4-leaf crop to maturity, and; ii) continuous flood irrigation interrupted (RI) during the growing season (paddy soil was drained 15 days before panicle differentiation, and was again flooded until maturity). Each subplot was subdivided with the following fertilization treatments at the moment of planting: a) control, without of P and Zn (*T*); b) fertilization with 200 kg ha^{-1} of calcium triple superphosphate (20% P), equivalent to 40 kg P ha^{-1} (+ *P*); c) fertilization with Zn, at a rate of 25 kg ha^{-1} $ZnSO_4.7H_2O$ (22% Zn) (+ *Zn*) and d) fertilization with P and Zn, combining the treatments (+ P) and (+ Zn) (+ *P* + *Zn*).

b) Experiment 2

During the 2011/12 and 2012/13 in the localities of La Paz, San Salvador and Los Conquistadores, province of Entre Rios, Argentina, three field studies were developted in a split plot design in the farm field, with three replications. In the locality of La Paz soil was classified as Mollisol and in the other two sites as Vertisols. The main plot was divided by the addition of As at moment of planting: i) no addition; and ii) addition of As (As +) at a rate of 10 kg $ha^{-1}$of $NaAsO_3.7H_2O$. Each subplot was subdivided with the following fertilization treatments at moment of planting: a) control, without addition of P or Zn (*T*); b) fertilization with 200 kg ha^{-1} of calcium triple superphosphate (20% P), equivalent to 40 kg P ha^{-1} (+ *P*); c) fertilization with Zn, at rate of 25 kg ha^{-1} $ZnSO_4.7H_2O$ (22% Zn) (+ *Zn*) and d) fertilization with P and Zn, combining the treatments (+ P) and (+ Zn) (+ *P* + *Zn*). All sites were managed in continuous flood irrigation (RC) from the state 4-leaf crop to maturity and plague control.

The six sites were managed using local farmer practices of nitrogen fertilization, and weeds/pests control. In all cases, the variety of rice sown was long thin indica tipe. The rice seed was sown directly on dry soil. Surface water accumulated in reservoirs was used for irrigation. Flood irrigation was managed with levees, with a water table of 5-10 cm. The main characteristics of the soils that are relevant for these field trips can be seen in table 1.

Table 1: Soi characteristic in the experimental sities

	San Ramón 2012	Santa María 2012	Santa María 2013	San Salvador 2011	La Paz 2012	Los Conquistadores 2012
Organic Mater (%)	3.13	3.66	2.38	2.7	3.5	4.7
pH	6.66	6.11	5.38	6.8	5,8	5.1
P - Bray(mg kg^{-1})	8.3	17.9	5.4	4.4	7,8	4.1
Zn - EDTA(mg kg^{-1})	0.85	0.63	0.74	0.76	1.3	0.75
Total As (mgkg^{-1})	2.9	3.3	3.2	2,3	1,6	3.4
Available As (mg kg^{-1})	0.57	0.38	0.76	0.92	0.46	0.61
Clay (%)	37.2	34.4	33.8	41.2	27.3	35.1
Silt (%)	59.2	60.8	61.1	53.3	49.4	63.2
Sand (%)	3.6	4.8	5.1	3.9	22.7	2.5

c) Yield components

The variables evaluated were: yield at 14% moisture content (kg ha^{-1}), the biomass of straw (kg ha^{-1}), the number of panicles per m^{-2}, the numbers of total and filled grains per panicle, the empty grains, and the 1000 grain weight (g).

d) Analysis in plant tissues

The concentration of total elements, K, P, and Zn, in whole-grain paddy rice and straw was evaluated. The material was dried at an oven at 60°C for 48 hours and ground to a size below 1 mm. One gram of plant material was digested with an acid mixture of HNO_3 and $HClO_4$, the residue was filtered by washing with distilled water to a volume of 100 ml, and the concentration of the elements was determined. P was colorimetrically quantified by the Murphy-Rileymethod; K by flame photometry, and Zn by atomic absorption spectrophotometry. Total nitrogen was quantitated by distillation of ammonium after acid digestion by the Kjeldahl method. The arsenic content in the grains was analyzed by microwave digestion and quantified by mass spectrometry inductively coupled plasma.

e) Statistical analysis

Analysis of variance and mean comparison test was performed using "Infostat©" software.

III. Results

a) Experiment 1

The effect of irrigation management was not significant in the productivity of rice straw, and grain (Table 2), in agree with the results obtained by Xu et al. 2008. However, had a very significant effect on the

concentration of total As in grain, which was reduced from 0.60 mg kg^{-1} in continuous irrigation to 0.35 mg kg^{-1} in interrupted irrigation (Figure 1). In the same direction, it was observed that the percentage of empty grains decreased from 16 to 13% (Table 2).

By reducing the irrigation input, the N in grain dropped from 1.09 to 1.02% and P from 0.24 to 0.21%. There were no significant changes in the concentration of the other elements analyzed in grain and stubble by the effect of irrigation management (Table 3).

Although the effect of the experiment site was very significant, there was no interaction site by the treatments.

Table 2: Effect of irrigation management and fertilization on yield components (mean values for the three sites tested)

Treatment	Straw biomass (t ha^{-1})	Grain yield (t ha^{-1})	Panicles (N° m^{-2})	Total grains $panicle^{-1}$	Filled grains $panicle^{-1}$	Empty grains (%)	1000 grain weight (g)
RC	8.5 ab	10.3 bc	541 c	78	63	16.3 ab	28.4 bc
RC+P	8.1 ab	10.4 c	537 bc	81	68	15.5 ab	28.0 bc
RC+Zn	7.6 a	9.2 a	501 ab	76	64	15.4 ab	27.9 bc
RC+P+Zn	7.6 a	9.3 ab	505 abc	79	65	16.8 b	25.8 a
RI	8.5 ab	10.3 c	526 abc	76	66	13.1 a	27.7 b
RI+P	7.9 ab	9.9 abc	498 a	79	68	13.4 ab	27.6 b
RI+Zn	7.7 ab	9.7 abc	511 abc	82	71	13.5 ab	28.7 c
RI+P+Zn	8.7 b	10.3 bc	496 a	76	66	12.7 a	26.3 a

RC: continuous flood irrigation, RI: continuous flood irrigation interrupted. Different letters indicate significant differences (Fisher p≤0.05)

The fertilization treatments had little effect on yield, low interaction with irrigation management, and did not affect the concentration of As or other nutrients evaluated in the grain. This was manifest in the control treatment (no addition of P or Zn), which showed the highest number of panicles m^{-2} and increased yields (Figure 1).

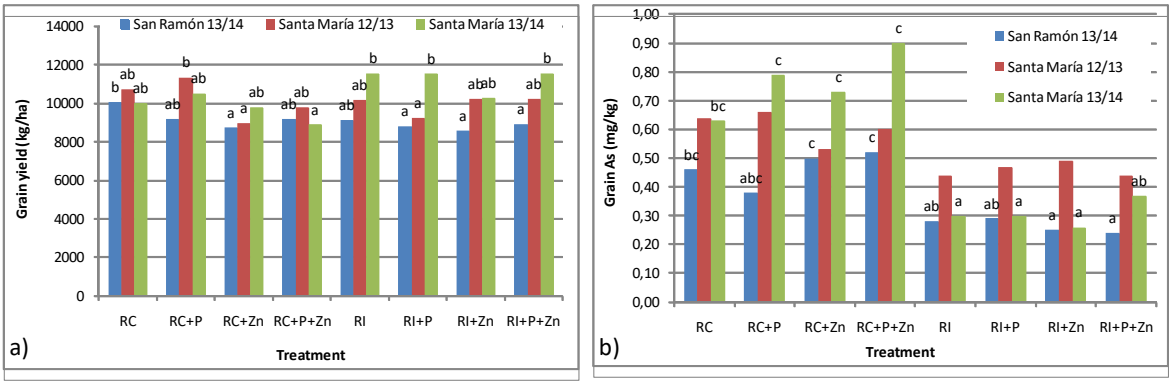

Figure 1: Yield (a) and concentration of total As in grain (b) according to treatment and tested site

Table 3: Concentration of total elements in grain and straw by treatment (mean values for the three sites tested)

Treatment	Grain					Straw			
	As (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mgkg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})
RC	0.56 b	1.07 cd	0.23 bc	0.14	23.2	0.66 b	0.10	1.35 a	34.4 a
RC +P	0.59 b	1.09 d	0.22 abc	0.15	23.5	0.65 b	0.11	1.60 ab	40.8 ab
RC +Zn	0.67 b	1.07 cd	0.24 c	0.16	23.9	0.62 ab	0.11	1.76 b	44.1 b
RC +P+Zn	0.65 b	1.06 bcd	0.24 c	0.16	24.3	0.63 ab	0.11	1.59 ab	39.9 ab
RI-	0.34 a	1.03 abc	0.22 ab	0.14	25.5	0.65 b	0.11	1.62 ab	45.0 b
RI-+P	0.35 a	1.01 a	0.23 ab	0.16	25.8	0.64 b	0.11	1.51 ab	45.8 b
RI-+Zn	0.33 a	1.03 abc	0.21 a	0.15	25.9	0.62 ab	0.11	1.60 ab	47.9 b
RI-+P+Zn	0.35 a	1.02 ab	0.21 a	0.15	27.0	0.59 a	0.11	1.71 b	43.3 ab

RC: continuous flood irrigation, RI: continuous flood irrigation interrupted. Different letters indicate significant differences (Fisher p≤0.05)

b) Experiment 2

The effect of treatments and site was very significant on most variables evaluated. There was a considerable interaction between the treatments and the sites on yield and As concentration in grain (Figure 2).

Yeld components showed no significant interaction and are summarized in Table 4.The yield was severely reduced by the application of As, especially in La Paz and to a lesser extent in San Salvador and Los Conquistadores. The decreased yield was related to a reduction in the number of panicles per square meter and the number of filled grains per panicle, and the increasing number of empty grains. The weight of grains was little affected (Table 4).

Table 4: Effect of adding As, P, and Zn on yield components (mean values for the three sites tested)

Treatment	Straw biomass (t ha^{-1})	Grain yield (tha^{-1})	Panicles (N° m^{-2})	Total grains panicle^{-1}	Filled grains panicle^{-1}	Empty grains (%)	1000 grain weight (g)
T	6.4 ab	7.2 c	522 d	106 c	83 c	21.3 a	22.8 ab
+Zn	6.9 ab	6.3 c	475 bc	97 abc	75 bc	23.3 a	23.5 b
+P	6.5 ab	6.7 c	465 abc	105 c	82 c	21.1 a	23.6 b
+P+Zn	7.3 a	6.9 c	474 bc	101 bc	78 bc	22.1 a	23.7 b
+As	6.5 ab	2.8 a	433 a	91 abc	51 a	44.8 b	22.7 ab
+As+Zn	6.3 ab	3.7 a	450 ab	89 abc	59 ab	36.8 b	23.1 ab
+As+P	6.4 ab	3.6 a	453 ab	84 ab	47 a	46.2 b	22.4 a
+As+P+Zn	6.1 b	4.8 b	487 c	82 a	50 a	41.4 b	23.4 ab

Different letters indicate significant differences (Fisher p≤0.05)

In treatments without the addition of As, applications of P and Zn had no significant effect on yield and on the absorption of nutrients (Figure 2).

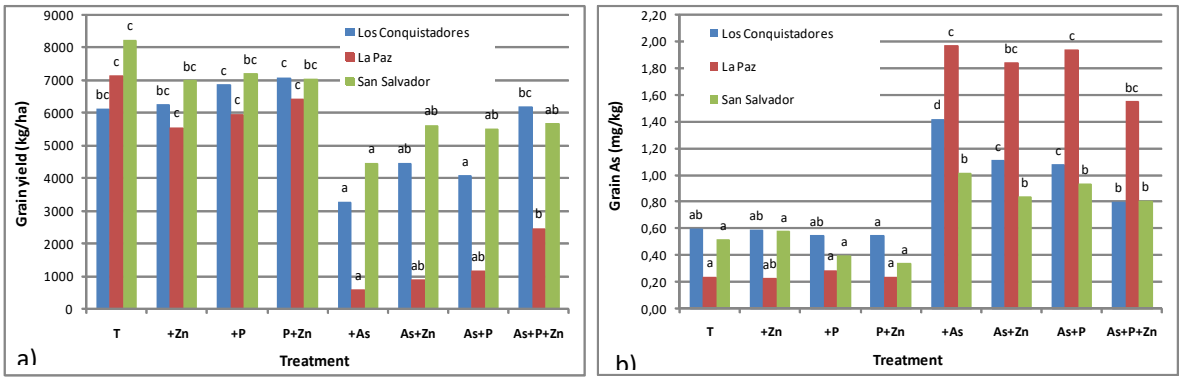

Figure 2: Yield (a) and concentration of total As in grain (b) according to treatment and tested site.

It was observed a close relationship between the As concentration in grains and rice yields (Figure 3), related to the reduction in the number of panicles m^{-2} and the number of filled grains per panicle whith increasing the number of empty grains (Table 4).

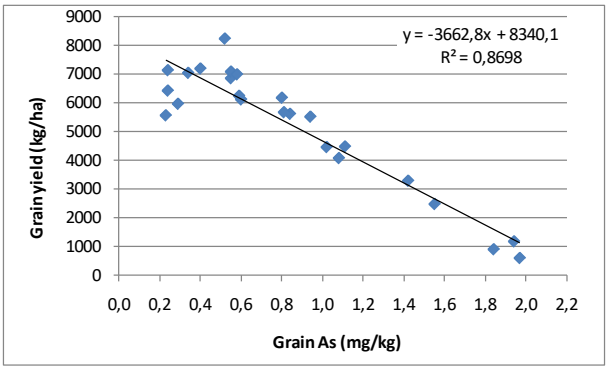

Figure 3: Correlation between as grain of rice and grain yield.

In the plots with As addition, the yield was severely reduced. However, the treatment with As plus P+Zn had a significant effect in lowering of total As in grain from 1.41 to 1.05 mg kg^{-1} (Table 5), accompanied by an increase in yield of 2.8 t ha^{-1} to 4.8 t ha^{-1} (Figure 2), whereas the application of As + P or As + Zn had no significant effect.

Table 5: Concentration of total elements in grain and straw by treatment (mean values for the three sites tested).

	Grain					Straw			
Treatment	As (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})	N (%)	P (%)	K (%)	Zn (mg kg^{-1})
T	0.45 a	1.01 a	0.26	0.18 ab	26.9	0.62 abc	0.09 a	1.79 b	27.5 abc
+Zn	0.47 a	1.02 ab	0.26	0.19 b	29.7	0.64 abcd	0.10 a	1.79 b	31.6 c
+P	0.41 a	1.01 a	0.27	0.19 b	28.2	0.58 a	0.10 a	1.74 b	25.8 abc
P+Zn	0.38 a	1.01 a	0.25	0.18 ab	29.8	0.59 ab	0.10 a	1.73 b	28.3 bc
+As	1.41 c	1.09 c	0.26	0.16 a	27.2	0.72 d	0.15 c	1.47 a	26.6 abc
As+Zn	1.26 bc	1.07 bc	0.25	0.18 ab	32.0	0.69 cd	0.13 bc	1.47 a	24.4 ab
As+P	1.43 bc	1.10 c	0.26	0.19 b	25.8	0.71 cd	0.14 bc	1.69 ab	22.6 ab
As+P+Zn	1.05 b	1.06 abc	0.26	0.19 b	29.6	0.67 bcd	0.12 c	1.68 ab	22.0 a

Different letters indicate significant differences (Fisher $p \leq 0.05$)

The concentration of P and Zn in grain was not affected by treatments. Addition of As only produced a lower concentration of K in grain and straw. Khan et al. (2010) observed a decrease in the concentration of P and K in grain with the application of As, indicating that As toxicity affect the absorption of these nutrients.

The As addition produced a reduction in the number of grains per plant and a greater concentration of N and P in the straw; these elements are possibly not translocated due to lack of destinations.

IV. Discussion

a) Effect of Irrigation

Alternative wetting-drying (AWD) Irrigation system is promoted as a way to save water. It is allowed to dry the soil surface for a few days between food irrigation events, depending on the stages of plant development. Differences in saving water whith respect to permanent floods can vary between 20-40%. A dry period would also promote the benefits of supply of some nutrients, better root development, and reduced bioavailability of As.

The soil-reducing conditions during the flood promote a release of AsV sorbed in Fe oxi-hidróxides (reductive dissolution), which is subsequently reduced to AsIII. In soils with a flood-aeration cycles, after draining, quick and simultaneous sorption and precipitation of As with Fe and Mn occurs, which reduces its bioavailability.

In the present study, as a result of the drying of soil, the concentration of total As in rice grain was significantly reduced compared to continuous flood irrigation. One aspect to note is that the As content of whole paddy grain (i.e., 0.35 mg kg^{-1} of total As in interrupted flood treatmen) is a value that ensures its use for human consumption because it is close to the maximum allowed value for polished rice and still lacks industrial process that removes husk and pericarp, which are components with more total As. Xu, et al. (2008) compared As contents in rice grain and soil in an aerobic system and another with permanent flooding; they observed a decrease of 10 to 15 times in the range of total As in unpolished rice grain, associated with a reduction of 7-16 times in the concentration of As in soil solution in the aerobic system.

Grain yields obtained were higher than average in the area and were not affected by water management, ranging from 9.2 to 10.4 t ha^{-1} (Table 2). This lack of significant differences gives advantages to the method of irrigation interrupted because with similar yields, a greater efficiency in water use is obtained and reduces the availability of As for growing rice.

The drying of soil or interruption of an aerobiosis during the vegetative growing season of the crop, can reduce the availability of some nutrient elements that often are more available in flooded soils. This was evident in the lower P content observed in grain in interrupted flood treatmen (Table 3). As soils dry after draining the plot, compounds of Fe and Al react with P to form insoluble phosphates, reducing their availability. This fixation of P is stronger and less reversible under flood and drying alternating conditions than under conditions of continuous moisture or flooding (Snyder and Slaton, 2003).

b) Arsenic

The studied soils have an average total As content of 3.3 mg kg^{-1}, and water used for irrigation does not exceed 35μg l^{-1}. With these environmental

conditions, the average total As in white rice grain in the Noth Entre Ríos region is 0.45 mg kg^{-1}(Oteiza, et al., 2020). When a ratearound1 mg kg^{-1} of As was applied to the soil, there was a notable increase in the content of total As grains, tripling its natural value (Table 5).

A strong negative correlation was observed between rice yield and concentration of total As in grain (R2 = 0.87, Figure 3), matching results with those obtained by Xu et al. (2008). The highest bioavailability of As caused a reduction in the number of panicles m^{-2}, in the number of filled grains per panicle, and increased the grain sterility, which explained the reduction in yield (Table 4). Similar results were presented by Khan et al. (2010), showing significant reductions in the rice yields related to fewer tillers and grains per panicle produced by maximum addition of 20 mg kg^{-1} As.

The predominance of DMA species in Argentinian rice (Oteiza, et al., 2020) would be responsible for the grain sterility. Under the local conditions of soil and microbial flora, the continuous irrigation promotes a high availability of organic species of As and observation of a physiological disorder known as "Straight head", which produces a high percentage of empty and deformed grains (Panozzo et al., 2014). This increased availability of organic and inorganic As in soil, can be decreased with the oxygenation of paddy soil.Which was evidenced in our study, coinciding with results presented by Xu et al. (2008) where the soil addition of 10 mg kg^{-1} of As produces asignificant yield decreased in flood conditions, but did not effect on aerobic conditions.

c) Phosphorus

Phosphate added to the soil can compete with arseniate (AsV) and arsenite (AsIII) for the soil adsorption sites, decreasing the amount of As adsorbed, giving as a result, a greater availability of As.For thisreason, in flooded soils environments where AsIII is the dominant species, the application of phosphate could increase As toxicity. However, in both experiments, the plots that received an addition of P did not show an increase of As in grain.

Only when the availability of As was artificially higher, the combined addition of P and Zn was able to reduce the concentration of total As in grain, even though that value continued above the permissible level for human consumption (Table 5). Application of P in As-contaminated rice felds also led to Fe-plaque formation, leading to increased adsorption of As species of Fe-plaque and reduced As content in rice (Yang, et al. 2020). Some studies have shown the mitigating effect of P on Asuptake for rice, because arsenate enters the plant through the same transporters as phosphate. An example of this is noted by Sahoo et al. (2013), with a significant and negative relationship between As absorption for rice and the concentration of exchangeable soil P. Thus, the P application in alleviating As induced toxicity and reducing its level in rice grain is a suitable alternative Mishra, et al. 2022).

In Entre Rios, it has been recorded that the addition of P as fertilizer in rice crops, often depresses yield despite being soils with low availability of P. We hypothesize that the lack of response to P fertilization could be explained by release of soil native As with addition of phosphates, but ours results do reject this hypothesis because neither yield or concentration of total As in grain was affected.

d) Zinc

When zinc was added to soils with high As availability due to its application, a 26% decrease in total As content in the grain was observed; but only when Zn was combined with P fertilization. According to Das et al. (2007), this could be because Zn can react to form insoluble compounds with As and is not available to plants according to the reaction [arsenate + $ZnSO_4$→ Zn-arsenate + $SO_4^{=}$]. Studying the effect of fertilization with Zn on the mobilization of As in soil cultivated with rice using different management of water, they found that application of 25 kg ha^{-1} $ZnSO_4$ combined with interrupted irrigation decreased by 21% the concentration of As total grain rice without yield loss. In an incubation experiment, Das et al. (2016) used soil with low (3 mg kg^{-1}) to medium (18 mg kg^{-1}) total As content and recorded a decrease of 25-35% in available soil As by adding Zn doses between 2.5 to 5 mg kg^{-1}. Under field conditions, in soils with medium contents of total As and applying 20 $kgha^{-1}$ of SO_4Zn, they recorded a reduction of total As in all parts of the plant and especially in grain, which was reduced by 12-14% compared to control. This decrease would be attributed to the electrostatic interaction between As and Zn, which facilitates the formation of compounds of lower solubility.

V. Conclusions

This study has demonstrated a marked effect of irrigation management on As concentration in rice grains. Irrigation system with a drying in the vegetative period is a good practice that leads to a docreaced As soil availability with the consequent reduction of As in grains, without affecting yield.

Under natural conditions of low As soil availability, and permanent flooding, P and Zn fertilization did not improve yield or affect absorption As for rice cultivation. While, with external high As availability, yield was severely affected. But, the P plus Zn addition allowed to mitigation the toxic effect in some degree. A significant negative correlation between rice yield and concentration of total As in grain was explained by the increase in the percentage of empty grains.

These preliminary results in the study of the dynamics of As in soil-plant under field conditions are

esential to better understand As absorption by rice. In this way, it could develop effective management strategies to reduce As concentrations in rice grain. For the moment and under these conditions, drainage and drying of rice fields, along with a selection of varieties of lower absorption of As, are the best alternatives to reduce concentration of As in rice grains.

Acknowledgements

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Standardized Precipitation Index Valuation of the Impact of Climate Variability and Change on Domestic Water Accessibility in Bamenda III Municipality, North West Region, Cameroon

By Suiven John Paul Tume & Moye Eric Kongnso

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Keywords: *adaptation, water security, vulnerability.*

GJSFR-H Classification: *DDC Code: 551.5112 LCC Code: TD885.5.G73*

Strictly as per the compliance and regulations of:

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I. Introduction

Water accessibility is the proportion of the population with reliable improved drinking water. Such improved sources include piped water into a residence, public standpipes in a neighbourhood, boreholes, protected well, protected springs and rainwater harvesting. Climate change affects these water sources in multiple ways, with complex spatio-temporal patterns, feedback and interactions between physical and human processes (Bates *et al.*, 2008). These effects are already adding challenges to sustainable water resources management, which are already under severe pressure in many regions of the world and are subject to high climate variability and extreme weather events (Stewart *et al.,* 2020; Baninla *et al.,* 2022). The main effects of climate change on water resources include accessibility, availability, quality and quantity of water for basic human needs (water security), threatening the effective enjoyment of the human rights to water and sanitation. Although the effects can be highly individual at the local scale (Intergovernmental Panel on Climate Change-IPCC, 2019; Tanwie *et al.,* 2022; Baninla *et al.,* 2022), current trends and future projections indicate major shifts in climate, and more extreme weather events in many parts of the world (IPCC, 2014). It is therefore paramount that water resources managers consider the potential impacts of a changing climate when planning for water resources development.

This study bridges some methodological gaps identified in previous works like Zotem and Nfor (2020) who analysed rainfall variability and quantity of water supply in Bamenda I. These authors used a household questionnaire, Standardized Precipitation Index (SPI) and Seasonality Index (SI), but did not assess water accessibility through springs, streams, the spatial distribution of public taps as well as basics such as distances covered by households to the nearest water points. Although they used major climatic indices such as SPI and SI, they failed to show detailed decadal variations and consequences on water supply. In other studies, Tume (2019, 2021a and b, 2022 a and b) used SPI and SI respectively to assess the vulnerability of water resources to climate variability on the Bui Plateau but failed to assess the state of other water sources on which households rely on springs, streams, wells and boreholes. Chiaga *et al.,* (2019) examined watershed management and the sustainability of the urban water supply in Bamenda. The authors revealed that the Bamendankwe Highland is the main watershed of Mezam Division of the North West Region of Cameroon. These researchers, however, did not take into account the role of climate change in water resources dynamics in the city of Bamenda. Furthermore, Wirba *et al.,* (2020) explored water management practices and sustainability implications in the Bamenda metropolis. Although the study covered the entire city of Bamenda, only two neighbourhoods were selected in the Bamenda III municipality, that is, Mile IV and Mile VI, where 40 questionnaires were administered. Given that Bamenda

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III is the second most populated municipality in the metropolis, with 55 neighbourhoods and a population of over 230,000 inhabitants, a sample of 40 was not representative enough. This paper, therefore, attempts to blend the role of climate change on water accessibility in Bamenda III, using a household questionnaire and a detailed analysis of climatic data.

Local hydrological changes induced by climate change imply major risks for society, not only directly through alterations in the hydro-meteorological processes that govern the water cycle, but also indirectly through risks for energy production, food security, economic development and social inequalities, among others (Figure 1).

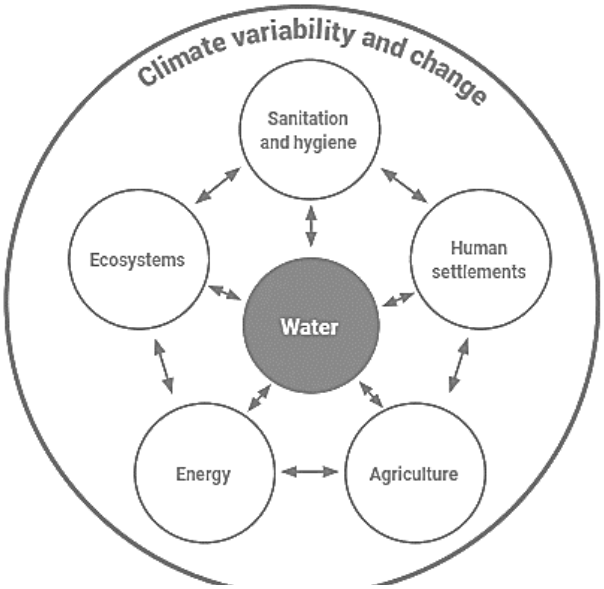


Figure 1: Interactions between water and other major socio-economic sectors affected by climate variability and change. Source: Stewart *et al.,* 2020

Climate change adaptation and mitigation through water management is therefore critical to sustainable development, and necessary to achieve the 2030 Agenda for Sustainable Development, the Paris Agreement and the Sendai Framework for Disaster Risk Reduction. This paper falls within the context of the global development agenda, with an overarching emphasis on some Sustainable Development Goals (SDGs), namely SDG-6 (ensure availability and sustainable management of water and sanitation for all), SDG-11 (sustainable cities and communities) and SDG-13 (take urgent action to combat climate change and its impacts).The impacts of climate change on urban and semi-urban water systems include higher temperatures, reduced precipitation and recurrent meteorological and hydrological droughts on the one hand, and increasing heavy precipitation and flooding events on the other (Smith *et al.,* 2019). It is precisely these extremes that make the planning of urban space and the provision of infrastructure so difficult (Tume, 2022). Urban water resilience goes way beyond the traditional city boundaries. In cases where water supplies rely on distant watersheds, planning needs to look well beyond the city's boundaries and consider the long-term impacts of urban expansion on distant freshwater ecosystems and the local communities that also rely on them (World Bank, 2011).

II. Study Area and Methodology

The Bamenda III Municipality is found in Mezam Division of the Northwest Region of Cameroon, located between Longitude 10°10'0" and 10°14'0" East of the Greenwich Meridian and Latitude 5°56'0" and 6°0'0" North of the Equator (Figure 2).

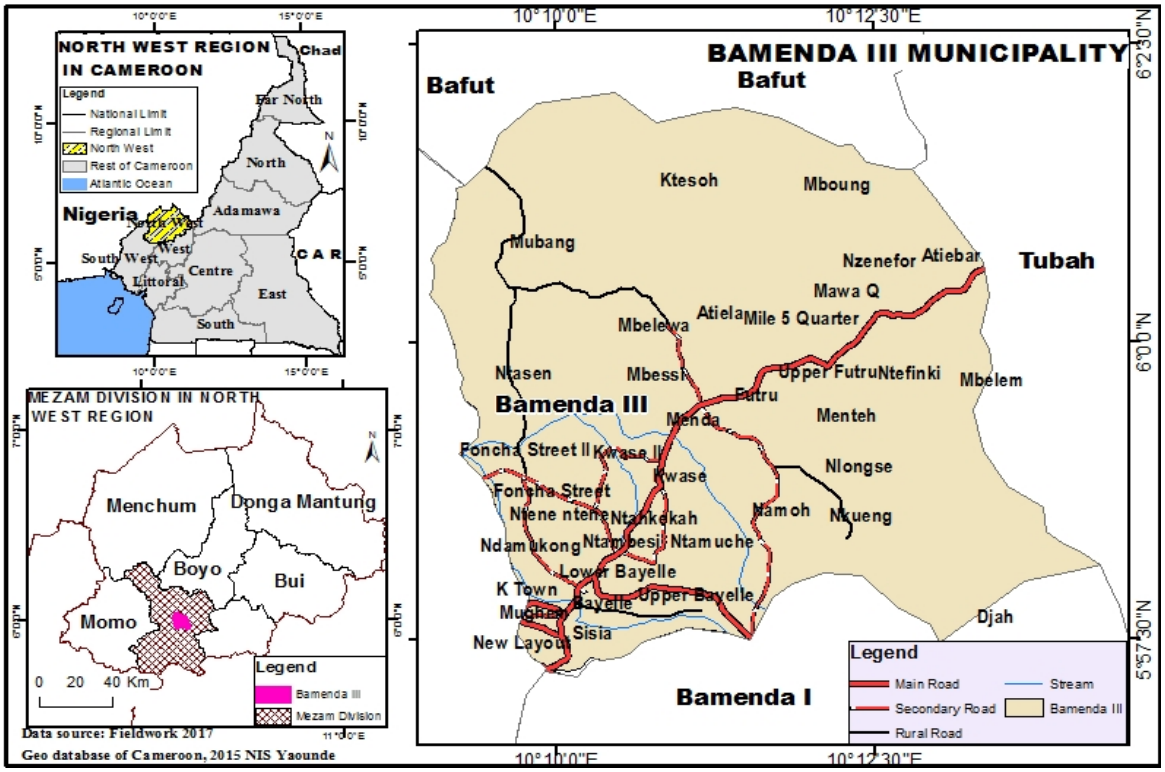


Figure 2: Location of Bamenda III Sub-Division

The area has boundaries with Bafut to the North, Tubah to the West, Bamenda II to the East and Bamenda I to the South. Characteristic features of Bamenda III municipality include hills ranging from steep to gentle slopes, but much of the area especially its urban site is a low land area lying in the flood plain of River Mezam and below the Bamendakwe escarpment at Up-Station. Features in the lowland include wetlands and many streams with altitudes ranging from 1,200-1,500m above sea level. There are two main villages, Nkwen with 46 neighbourhoods and Ndzah with 9 neighbourhoods (Tume, 2021 b).

Primary data was in the form of a household questionnaire, which was administered in 10 neighbourhoods in Nkwen and two neighbourhoods in Ndzah. A total of 269 questionnaires were administered (Table 1). The choice of these neighbourhoods is because the spatial distribution represents all of the study areas. In addition, the 12 neighbourhoods in both villages represent 20% of the surface area of the study and 10% of the total population. Secondary data was rainfall, collected from the Regional Meteorological Service at the Northwest Delegation of Transport for a period of 56 years (1963-2019). Some current literature on climate and water resources was also appreciated from UN-Water Development Reports and journals. The household questionnaire was treated in the Statistical Package for Social Sciences (SPSS) Version 20. A cross-tabulation of various variables under treatment were established and exported into Microsoft Excel 2016.

Table 1: Distribution of questionnaires

Village	Neighbourhood	Questionnaires administered
Nkwen	Atielah-Mbelewa	24
	Atiesu-Mbessi	15
	Bayelle I	22
	Bunjong-Mambu	19
	Futru I	31
	Lower Menteh	9
	Manka-Mambu	34
	Nchang-Ntambang	44
	Sisia I	11
	Mubang	20
Ndzah	Mokop	13
	Terrekoh	27
	Total	269

This entailed calculation of percentages and the establishment of tables and charts. The climatic data were treated in Microsoft Excel 2016, where monthly and inter-annual graphs were generated. Rainfall data were further analysed using the Standardized Precipitation Index (SPI), a tool that was developed primarily for defining and monitoring drought. It allows an analyst to determine the rarity of a drought at a given time scale (temporal resolution) of interest for any rainfall station with historic data. It can also be used to determine periods of anomalously wet events. Conceptually, SPI is the number of standard deviations by which the precipitation values recorded for a location would differ from the mean over certain periods. In statistical terms, the SPI is equivalent to the Z-score.

$Z - score = x - \frac{\mu}{\delta}$; Where: Z-score expresses the *x* score's distance from the mean (μ) in standard deviation (δ) units. Statistically, the SPI is based on the cumulative probability of a given rainfall event occurring at a geographic location (Table 2).

Table 2: Drought probability of recurrence

SPI Value	Category	Probability (%)	Freq. in 100 years	Severity of event
>2.00	Extreme wet	2.3	100	1 in 1 year
1.5 to 1.99	Severely wet	4.4	70	1 in 1.1 years
1.00 to 1.49	Moderately wet	9.2	50	1 in 1.3 years
0 to 0.99	Mildly Wet	34.1	45	1 in 1.5 years
-0.1 to -0.99	Mild dryness	34.1	33	1 in 3 years
-1.00 to -1.49	Moderate dryness	9.2	10	1 in 10 years
-1.50 to -1.99	Severe dryness	4.4	5	1 in 20 years
<-2	Extreme dryness	2.3	2.5	1 in 50 years

Source: McKee et al., (1993, 1995); World Meteorological Organisation (2012)

SPI was used to assess the occurrence of drought incidents. All anomaly graphs generated from the data were fitted with trend lines and linear equations. The trend lines indicate an increase or decrease in the elements under study. Other measures of central tendencies for rainfall included Standard Deviation (σ) and Coefficient of Variation (CV). CV is calculated thus:

$\sigma = \frac{\sqrt{\Sigma(Y - \bar{Y})^2}}{N}$, $CV = \sigma * \frac{100}{\bar{Y}}$, Where: $\bar{Y}$=mean, N = sample size

III. Results

The results for this paper are sub-divided into climate variability and change, as well as the impact of climate variability and change on water accessibility.

a) Climate Variability and Change

Climate change is the statistical variations in the properties of the climate system such as changes in temperatures, precipitation, and other climatic elements due to natural or human drivers over a long period. Climate change could drastically alter the distribution and quality of natural resources, thereby adversely affecting the livelihood security of the people (IPCC, 2018). The population of Bamenda III perceive that the magnitude of climate variability is high (Figure 3).

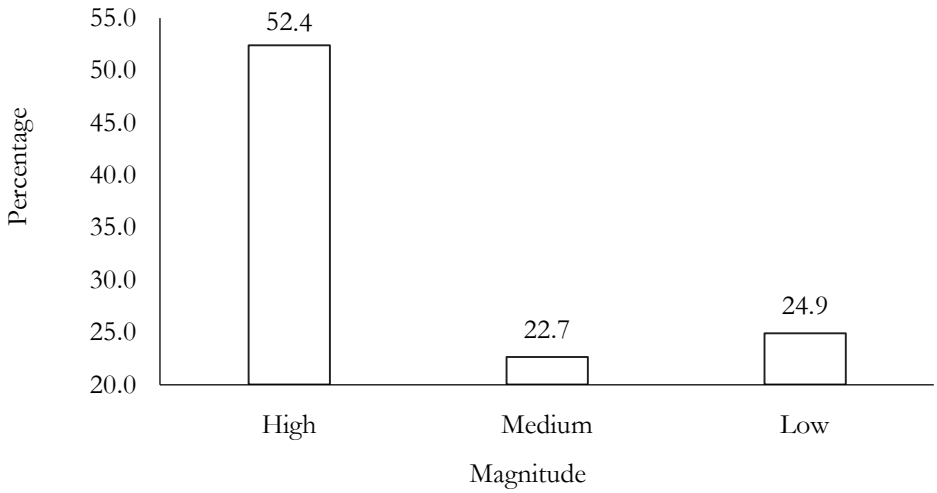
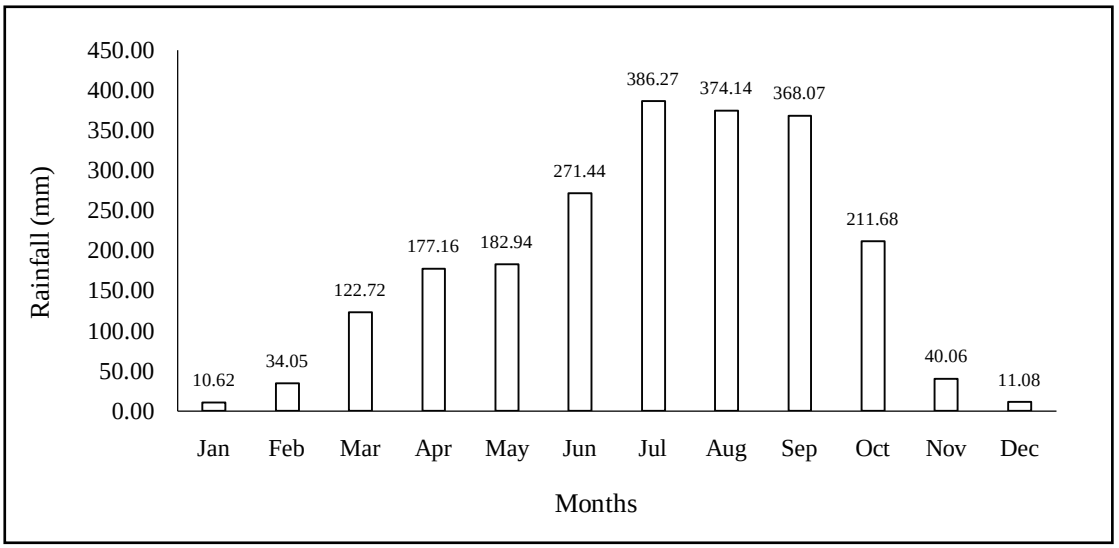


Figure 3: Magnitude of climate variability in Bamenda III

Field data revealed that 54.4% of the population perceived a high magnitude, while 24.9% perceived a low magnitude and 22.7% perceived that the magnitude is moderate. Sources of climate information are diverse. The majority of the people receive climate-related information from television (45%), followed by seminars (23%), radio (21%), government agencies (6%) and the internet 5%). This proves that the population of Bamenda is well informed about changing climatic conditions as none of the field responses did not indicate that they do not receive any climate-related information.

b) Actual climate variability and change

Rainfall in Bamenda increases from the onset of the wet season to a peak in July to September and gradually drops as the dry season sets in (Figure 4).



Data source: Regional Meteorological Service, Northwest

Figure 4: Mean monthly rainfall for Bamenda

The lowest rainfall is recorded from December to March. To assess how much rainfall has changed, the data were grouped into 3-month segments (Table 3).

Table 3: Rainfall change over Bamenda (1963-2019)

	Decadal mean rainfall (mm)					
Months	1963-1972	1973-1982	1983-1992	1993-2002	2003-2012	2013-2019
DJF	25.07	19.85	16.5	9.7	17.71	24.5
MAM	184.17	161.78	158.82	149.1	138.9	178.01
JJA	387.6	361.9	364.2	356.4	325.9	235.06
SON	238.81	240.9	202.5	210.9	195.97	126.5
Mean	208.91	196.11	185.51	181.53	169.62	141.02
Change	26.39	13.59	2.98	-1.00	-12.90	-41.50

DJF: December, January, February; MAM: March, April, May, JJA: June, July, August, SON: September, October, November

From 1963-1972, rainfall had an excess of 26.39 mm and has been declining over time. Between 1973-1982, the rainfall dropped by 13.59 mm and 2.98 mm from 1983-1992. Since 1993, Bamenda has witnessed rainfall deficits (-1 mm from 1993-2002, -12.9 mm from 2003-2012 and -41.5 mm from 2013-2019). The average rainfall decline from 1963-2019 is -2.07 mm. This proves that the climate is changing and is affirmed by the declining inter-annual rainfall trend (Figure 5).

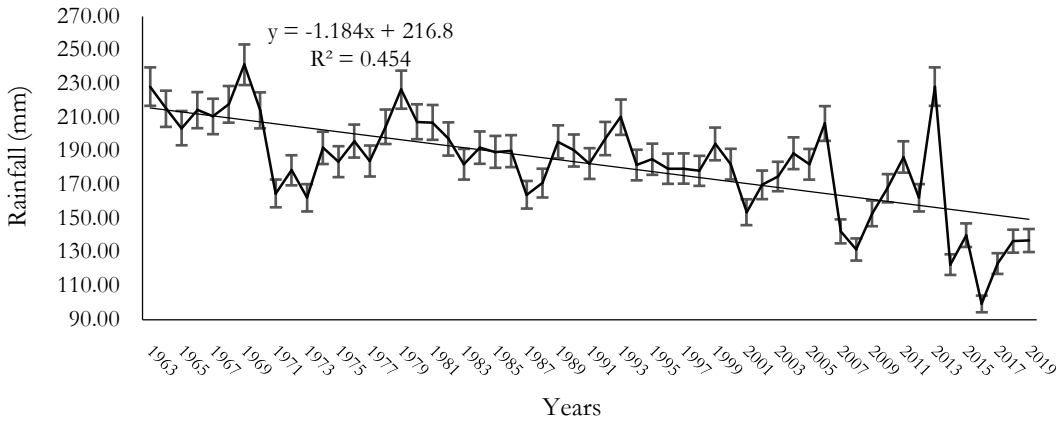


Figure 5: Inter-annual rainfall for Bamenda (1963-2019)

The mean annual rainfall for Bamenda is 182.52 mm, with a Standard Deviation (SD) of 29.16 and a Coefficient of Variation (CV) of 15.96% (reliable). The climatic index used in assessing climate variability and change for this study is SPI. The SPI inter-annual pattern is the same as the inter-annual rainfall, with the same Coefficient of Determination (R^2) of 0.4548 (45.48%) (Figure 6).

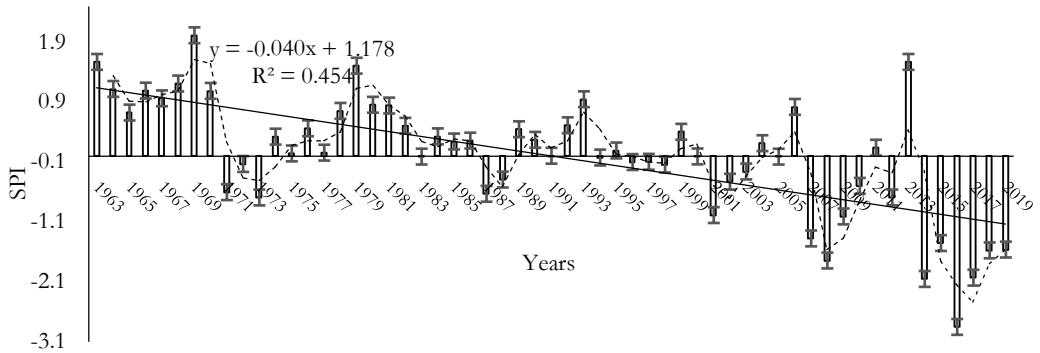


Figure 6: Inter-annual Standardized Precipitation Index for Bamenda (1963-2019)

Additional understandings of rainfall change over Bamenda are better presented through decadal SPI trends. From 1963-1972, the SPI trend decreased above the average (Figure 7).

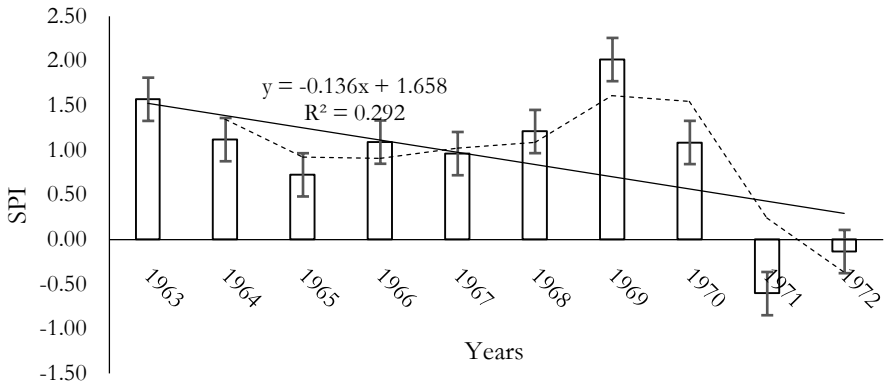


Figure 7: Standardized Precipitation Index for Bamenda (1963-1972)

The SPI episodes were 1963 (1.57-moderately wet), 1964 (1.12-moderately wet), 1965 (0.73-mildly wet), 1966 (1.09-moderately wet), 1967 (0.96-mildly wet), 1968 (1.21 (moderately wet), 1969 (2.02-extreme wet), 1970 (1.09-moderately wet), 1971 (-0.6-mild dryness) and 1972 (-0.13-mild dryness). Eight out of the ten years of this decade were wet years, except 1971 and 1972. The dry years continued till 1973. The decade 1973-1982 experienced an increasing SPI trend, with nine wet years out of ten (Figure 8).

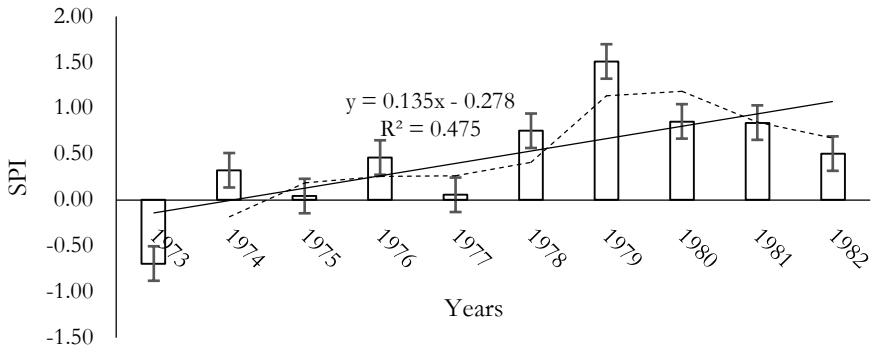


Figure 8: Standardized Precipitation Index for Bamenda (1973-1982)

The SPI episodes were 1973 (-0.69-mild dryness), 1974 (0.32-mildly wet), 1975 (0.04-mildly wet), 1976 (0.46-mildly wet), 1977 (0.06-mildly wet), 1978 (0.75-mildly wet), 1979 (1.51-moderately wet), 1980 (0.86-mildly wet), 1981 (0.84-mildly wet) and 1982 (0.51-mildly wet). The SPI trend increased above the average from 1983 to 1992 (Figure 9).

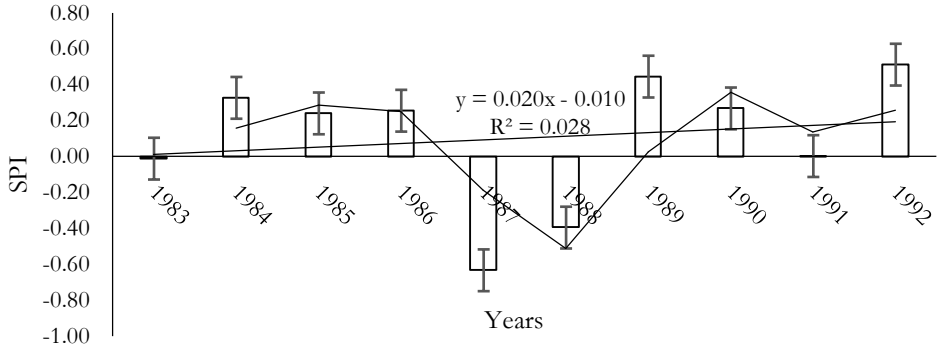


Figure 9: Standardized Precipitation Index for Bamenda (1983-1992)

In 1983, the SPI value was (-0.01-mild dryness), 1984 (0.33-mildly wet), 1985 (0.24-mildly wet), 1986 (0.26-mildly wet), 1987 (-0.63-mild dryness), 1988 (-0.39-mild dryness), 1989 (0.45-mildly wet), 1990 (0.27-mildly wet), 1991 (0-mildly wet) and 1992 (0.51-mildly wet). The 1993 to 2002 period can be seen as a dry decade, with a decreasing SPI trend and seven years of negative SPI (Figure 10).

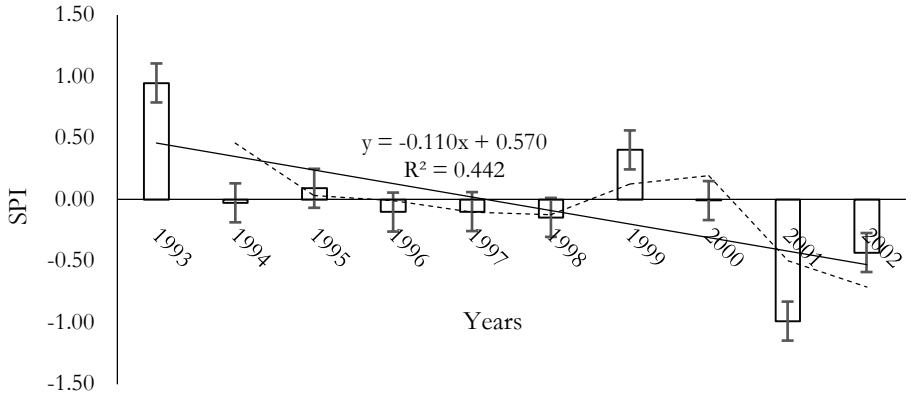


Figure 10: Standardized Precipitation Index for Bamenda (1993-2002)

The SPI episodes were 0.95 (mildly wet) in 1993, 1994 (-0.03-mild dryness), 1995 (0.09-mildly wet), 1996 (-0.10-mild dryness), 1997 (-0.10-mild dryness), 1998 (-0.14-mild dryness), 1999 (0.4-mildly wet), 2000 (-0.01-mild dryness), 2001 (-0.99-mild dryness) and 2002 (-0.43-mild dryness). The 2003 to 2012 period was also another dry decade, with a decreasing SPI below the average (Figure 11).

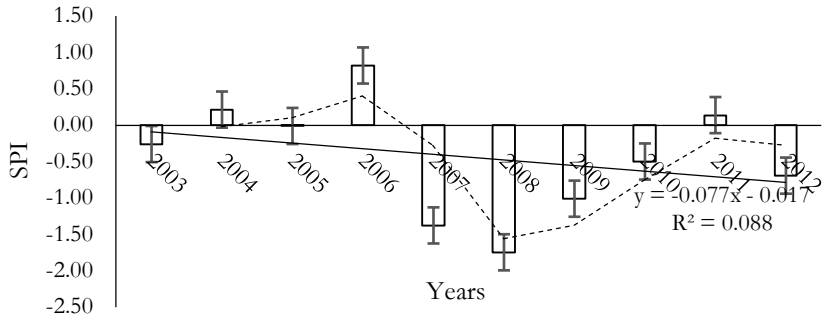


Figure 11: Standardized Precipitation Index for Bamenda (2003-2012)

The SPI values were, 2003 (-0.26-mild dryness), 2004 (0.21-mildly dry), 2005 (-0.01-mild dryness), 2006 (0.82-mildly wet), 2007 (-1.38-moderate dryness), 2008 (-1.75-severe dryness), 2009 (-1.01-moderate dryness), 2010 (-0.50-mild dryness), 2011 (0.14-mild dryness and 2012 (-0.69-mild dryness). From 2013 to 2019, the SPI continued to decline below the average (Figure 12). It is also another dry decade.

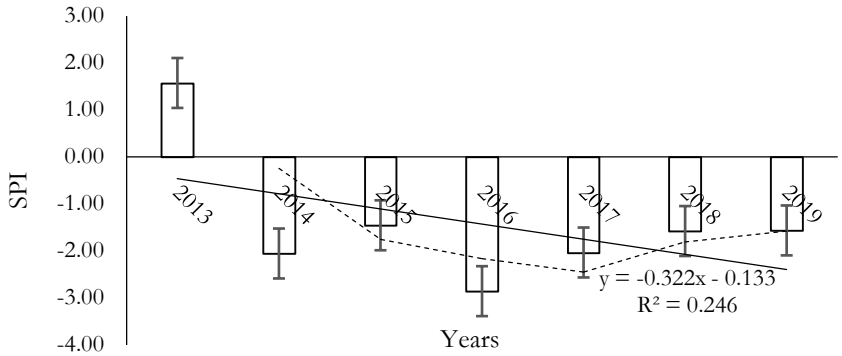


Figure 12: Standardized Precipitation Index for Bamenda (2013-2019)

The SPI incidents were, 2013 (1.57-severely wet), 2014 (-2.06-extreme dryness), 2015 (-1.46-moderate dryness), 2016 (-2.86-extreme dryness), 2017 (-2.03-extreme dryness), 2018 (-1.58-severe dryness) and 2019 (-1.56-severe dryness). Rainfall and SPI characteristics for Bamenda can be summarized (Table 4).

Table 4: Summary of rainfall characteristics and SPI

Period	MAR (mm)	SD	CV (%)	Mean SPI	SPI class	R^2	Trend	Reliability
1963-1972	208.92	22.34	10.69	0.91	Mildly wet	0.2927	Decreasing	Reliable
1973-1982	196.1	17.33	8.84	0.47	Mildly wet	0.4752	Increasing	Reliable
1983-1992	185.52	10.73	5.78	0.1	Mildly wet	0.0286	Increasing	Reliable
1993-2002	181.51	14.61	8.05	-0.03	Mild dryness	0.4424	Decreasing below average	Reliable
2003-2012	169.62	22.89	13.49	-0.44	Mild dryness	0.0886	Decreasing below average	Reliable
2013-2019	141	40.95	29.04	-1.42	Severe dryness	0.246	Decreasing below average	Unreliable
Mean	180.445	21.50	12.65	-0.07	Mild dryness	0.2623	Decreasing	Reliable

MAR: mean annual rainfall, SD: Standard Deviation, CV: Coefficient of Variation, R^2: Coefficient of Determination

Rainfall was reliable from 1963 to 2012. Since 2013, dry episodes have been recurrent with a mean SPI of -1.42 and an unreliable CV of 29.04%. These characteristics show that rainfall has been deficient, thereby resulting in water scarcity. In all, the 1963-2019 period was characterised by 1 episode of extreme wet conditions (1969), 2 severely wet (1963, 2003), 5 moderately wet (1964, 1966, 1968, 1970, 1979), 23 mildly wet (1965, 1967, 1974, 1975, 1976, 1977, 1978, 1980, 1981, 1982, 1984, 1985,1986, 1989, 1990, 1991, 1992, 1993, 1995, 1999, 2004, 2006, 2011), 16 mild dryness (1971, 1972, 1983, 1987, 1988, 1994, 1996, 1997, 1998, 2000, 2001, 2002, 2003, 2005, 2010, 2012), 4 moderate dryness (1973, 2007, 2009, 2015), 3 severe dryness (2008, 2018, 2019) and 3 extreme dryness (2014, 2016, 2017) (Figure 13).

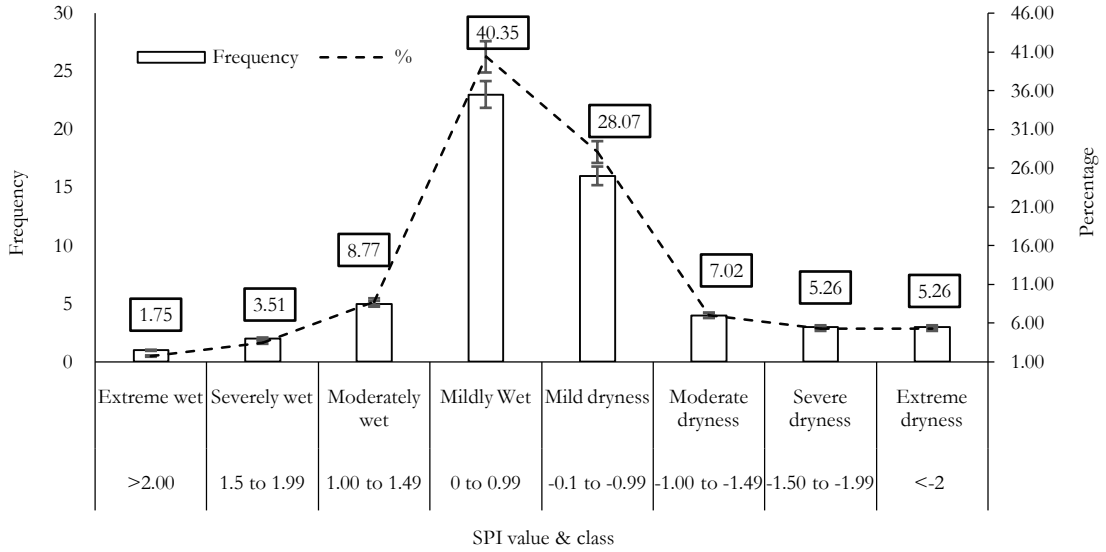


Figure 13: Standardized Precipitation frequency

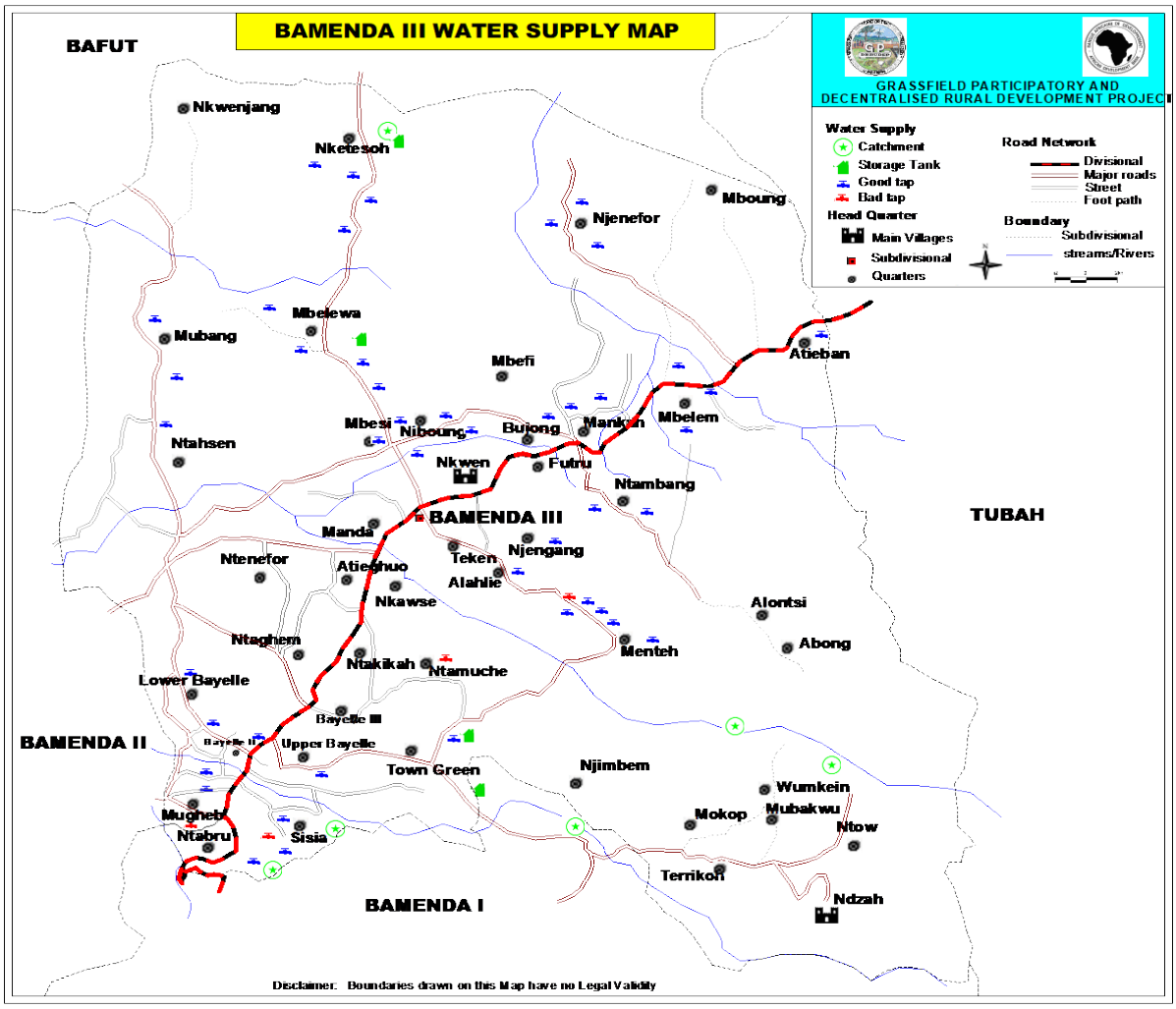
The overall mean SPI for the period under study is -0.07 (mild dryness) and a mean CV of 12.65% (reliable).

c) Domestic Water Accessibility

Sources of water in Bamenda III are public taps, streams, private taps, boreholes, protected springs, protected wells and unprotected springs (Table 5, Figure 14). The sampled neighbourhoods have at least one of the water sources, meaning that water is relatively accessible.

Table 5: Sources of domestic water in Bamenda III

Neighbourhoods	Public tap		Stream		Private tap		Borehole		Protected spring		Protected well		Unprotected spring	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Atielah-Mbelewa	6	12.50	5	10.87	6	6.12	2	10.00	3	16.67	1	5.88	1	4.55
Atiesu-Mbessi	1	2.08	2	4.35	5	5.10	3	15.00	1	5.56	2	11.76	1	4.55
Bayelle	4	8.33	3	6.52	8	8.16	1	5.00	1	5.56	1	5.88	4	18.18
Bunjong-Mambu	6	12.50	1	2.17	8	8.16	1	5.00	1	5.56	1	5.88	1	4.55
Futru I	5	10.42	9	19.57	12	12.24	1	5.00	1	5.56	2	11.76	1	4.55
Lower Menteh	1	2.08	2	4.35	2	2.04	1	5.00	1	5.56	1	5.88	1	4.55
Manka-Mambu	10	20.83	3	6.52	14	14.29	3	15.00	1	5.56	2	11.76	1	4.55
Nchang-Ntambang	8	16.67	6	13.04	22	22.45	2	10.00	2	11.11	2	11.76	2	9.09
Sisia I	1	2.08	2	4.35	1	1.02	1	5.00	1	5.56	1	5.88	4	18.18
Mubang	3	6.25	8	17.39	5	5.10	1	5.00	1	5.56	1	5.88	1	4.55
Mokop	1	2.08	2	4.35	4	4.08	2	10.00	1	5.56	1	5.88	2	9.09
Terrekoh	2	4.17	3	6.52	11	11.22	2	10.00	4	22.22	2	11.76	3	13.64
Total	48	100	46	100	98	100	20	100	18	100	17	100	22	100.00



Source: Bamenda III Council, 2012

Figure 14: Portable water supply in Bamenda III

The most accessible water sources are public taps, streams, private taps in homes and unprotected springs (at watersheds). The population gets water through head portage, wheelbarrows, cars and private water lines in households (Table 6).

Table 6: Means of getting water in Bamenda III

Neighbourhoods	Head		Wheelbarrow		Car		Private water line	
	F	%	F	%	F	%	F	%
Atielah-Mbelewa	10	6.54	4	21.05	3	7.89	7	11.86
Atiesu-Mbessi	11	7.19	0	0.00	1	2.63	3	5.08
Bayelle	13	8.50	1	5.26	2	5.26	6	10.17
Bunjong-Mambu	9	5.88	2	10.53	4	10.53	4	6.78
Futru I	25	16.34	0	0.00	5	13.16	1	1.69
Lower Menteh	0	0.00	1	5.26	1	2.63	7	11.86
Manka-Mambu	24	15.69	1	5.26	2	5.26	7	11.86
Nchang-Ntambang	25	16.34	4	21.05	8	21.05	7	11.86
Sisia I	5	3.27	3	15.79	2	5.26	1	1.69
Mubang	16	10.46	0	0.00	4	10.53	0	0.00
Mokop	1	0.65	2	10.53	1	2.63	9	15.25
Terrekoh	14	9.15	1	5.26	5	13.16	7	11.86
Total	153	100	19	100	38	100	59	100

Water accessibility in terms of distance to the nearest water point is related to water security. Water security is sustainable access, on a watershed scale, to adequate quantities of water of acceptable quality, to

ensure human and ecosystem health (Norman *et al.,* 2010). It is a multi-dimensional concept that recognizes that sufficient good quality water is needed for social, economic and cultural uses while, at the same time, adequate water is required to sustain and enhance important ecosystem functions. From another perspective, water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2018). In Bamenda III municipality, the majority of the people cover distances of less than 50 m water points (Table 7).

Table 7: Distances covered to the nearest water points

Neighbourhoods	<50 m		51-100 m		101-200 m		200 m+	
	F	%	F	%	F	%	F	%
Atielah-Mbelewa	8	5.84	6	13.64	5	11.90	5	10.87
Atiesu-Mbessi	9	6.57	3	6.82	0	0.00	3	6.52
Bayelle	12	8.76	6	13.64	1	2.38	3	6.52
Bunjong-Mambu	6	4.38	6	13.64	2	4.76	5	10.87
Futru I	18	13.14	0	0.00	10	23.81	3	6.52
Lower Menteh	4	2.92	2	4.55	1	2.38	2	4.35
Manka-Mambu	20	14.60	9	20.45	1	2.38	4	8.70
Nchang-Ntambang	21	15.33	6	13.64	8	19.05	9	19.57
Sisia I	3	2.19	4	9.09	2	4.76	2	4.35
Mubang	10	7.30	0	0.00	8	19.05	2	4.35
Mokop	7	5.11	1	2.27	0	0.00	5	10.87
Terrekoh	19	13.87	1	2.27	4	9.52	3	6.52
Total	137	100	44	100	42	100	46	100

Water insecurity sets in when people cover a distance of more than 200 m to carry drinking water and water for other domestic chores. In Bamenda III, a significant proportion (17.1%) of the population covers more than 200 m to get water. Water accessibility is directly linked to water availability for domestic chores. The basic domestic uses of water in Bamenda III like elsewhere are shower, laundry, toilet sanitation, house cleaning, doing dishes, cooking and drinking (Table 8).

Table 8: Domestic water chores

Chores	<5 L		6-10 L		11-15 L		16-20 L		21 L+	
	F	%	F	%	F	%	F	%	F	%
Shower	0	0.0	143	53.2	72	26.8	25	9.3	29	10.8
Laundry	0	0.0	28	10.4	34	12.6	75	26.4	132	49.1
Toilet flush/cleaning	106	39.4	79	29.4	64	23.8	8	3.0	12	4.5
House cleaning	59	21.9	58	21.6	42	15.6	75	27.9	35	13.0
Cleaning dishes	60	22.3	54	20.1	50	18.6	75	27.9	30	11.2
Cooking	23	8.6	79	29.4	60	22.3	75	27.9	32	11.9
Drinking	269	100.0	0	0	0	0	0	0	0	0
Average		27.5		23.4		17.1		17.5		14.3

On the average, majority of the people use about 6 to 10 litres every day, which falls below international standards, implying there is water scarcity to meet domestic needs. Water scarcity is caused by several factors, and climate change is one of the leading drivers (Table 9, Figure 15).

Table 9: Causes of scarcity in Bamenda III

Drivers	Options	Frequency	%
Irregular/unreliable rainfall	Yes	194	72.1
	No	50	18.6
	Don't know	25	9.3
Farming at watersheds	Yes	168	62.5
	No	58	21.6
	Don't know	43	16.0
Mismanagement of water projects	Yes	180	66.9
	No	67	24.9
	Don't know	22	8.2
Eucalyptus plantations at watersheds	Yes	149	55.4
	No	54	20.1

	Don't know	66	24.5
Grazing at watersheds	Yes	159	59.1
	No	70	26.0
	Don't know	40	14.9
Private land ownership at the watershed	Yes	151	56.1
	No	56	20.8
	Don't know	62	23.0
Deforestation in the watersheds	Yes	188	69.9
	No	31	11.5
	Don't know	50	18.6
Conflicting land uses at the watersheds	Yes	123	45.7
	No	53	19.7
	Don't know	93	34.6
Irregular repairs of leakages	Yes	202	75.1
	No	53	19.7
	Don't know	14	5.2

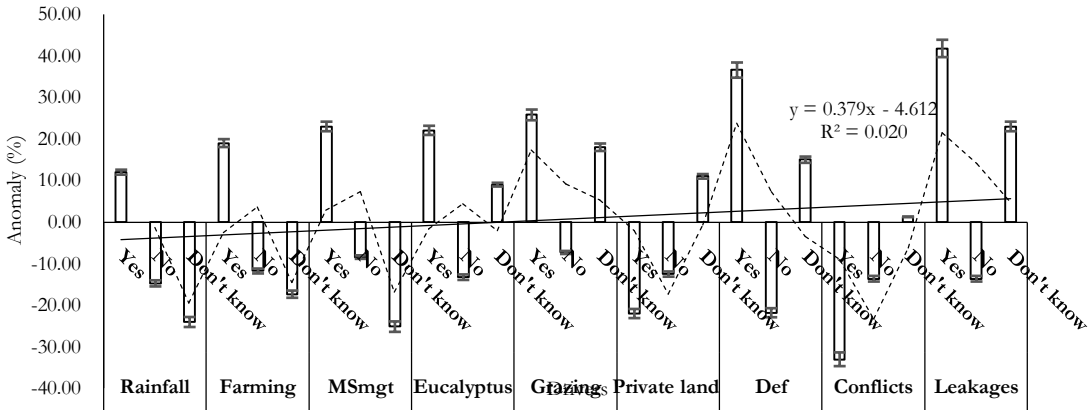


Figure 15: Trend in drivers of water scarcity in Bamenda III

The trend of water scarcity is increasing. The population perceived that unreliable rainfall contributes to 72.1% of the scarcity. This is affirmed by the rainfall data which proved that rainfall is becoming unreliable in Bamenda with an average CV of 29.04% for the period 2013 to 2019, and recurrent incidents of dryness through negative values of SPI for the same period. Other contributors to water scarcity are farming and grazing at watersheds, mismanagement of water projects, eucalyptus plantations around watersheds, private land ownership at watersheds, deforestation, conflicting water uses and irregular repairs of pipeline leakages. The peak periods of water scarcity are during the dry season when the water table is lowest (Figure 16).

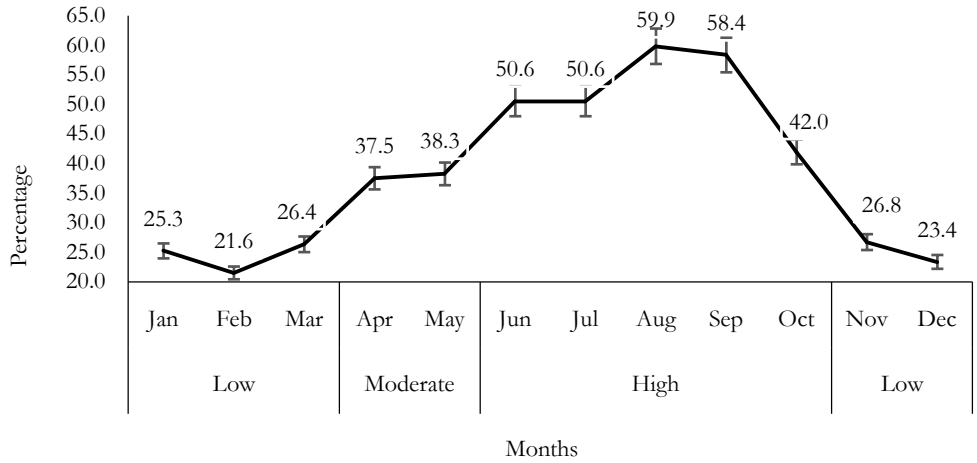


Figure 16: Annual fluctuation and reliability of domestic water supply in Bamenda III

The population's perception of low water availability from November to March coincides accurately with the dry season. Moderate water supply sets in April to May when people begin to collect rainwater to meet some of the domestic chores. Water availability is generally high from June to October when rainfall is relatively high. The perceived annual fluctuation and reliability of domestic water supply have the same patterns of mean monthly rainfall. The population of Bamenda III indicated that water scarcity is manifested through chronic water shortages, drying streams, periodic floods and rising temperatures (Table 10).

Table 10: Manifestation of water scarcity in Bamenda III

Neighbourhoods	Manifestation	Very Visible		Not Visible		Don't know	
		F	%	F	%	F	%
Atielah-Mbelewa	Chronic water shortages	19	10	5	10	0	0
	Drying streams	20	10	4	11	0	0
	Floods	10	13	9	8	5	7
	Rising temperatures	13	11	7	10	4	5
Atiesu-Mbessi	Chronic water shortages	9	5	2	4	4	17
	Drying streams	9	4	2	5	4	15
	Floods	2	3	6	5	7	10
	Rising temperatures	4	3	7	10	4	5
Bayelle	Chronic water shortages	15	8	4	8	3	13
	Drying streams	17	8	2	5	3	12
	Floods	4	5	12	10	6	8
	Rising temperatures	8	7	9	13	5	6
Bunjong-Mambu	Chronic water shortages	12	6	5	10	2	8
	Drying streams	10	5	5	14	4	15
	Floods	3	4	9	8	7	10
	Rising temperatures	6	5	5	7	8	10
Futru I	Chronic water shortages	25	13	5	10	1	4
	Drying streams	30	15	0	0	1	4
	Floods	18	23	9	8	4	6
	Rising temperatures	18	15	7	10	6	7
Lower Menteh	Chronic water shortages	5	3	4	8	0	0
	Drying streams	6	3	3	8	0	0
	Floods	3	4	5	4	1	1
	Rising temperatures	7	6	1	1	1	1
Manka-Mambu	Chronic water shortages	22	11	5	10	7	29
	Drying streams	24	12	3	8	7	27
	Floods	6	8	15	13	13	18
	Rising temperatures	10	9	15	21	9	11
Nchang-Ntambang	Chronic water shortages	32	17	8	15	4	17
	Drying streams	30	15	8	22	6	23
	Floods	11	14	19	16	14	20
	Rising temperatures	16	14	9	13	19	23
Sisia I	Chronic water shortages	10	5	1	2	0	0
	Drying streams	30	15	8	22	6	23
	Floods	4	5	4	3	3	4
	Rising temperatures	4	3	4	6	3	4
Mubang	Chronic water shortages	16	8	4	8	0	0
	Drying streams	30	15	8	22	6	23
	Floods	12	15	6	5	2	3
	Rising temperatures	12	10	4	6	4	5
Mokop	Chronic water shortages	8	4	5	10	0	0
	Drying streams	9	4	4	11	0	0
	Floods	3	4	9	8	1	1
	Rising temperatures	9	8	1	1	3	4
Terrekoh	Chronic water shortages	20	10	4	8	3	13
	Drying streams	21	10	5	14	1	4
	Floods	4	5	15	13	8	11
	Rising temperatures	10	9	2	3	15	19

All the sampled neighbourhoods have experienced all these manifestations, though in different intensities. In the face of these problems, the population has resorted to adaptation by water storage, rationing, restoration of watersheds, good governance, no farming and grazing at watersheds, rainwater collection, planting of environmentally friendly trees, parks and gardens (Town Green) water reserves and inculcating water resources management into the local development agenda (Figure 17).

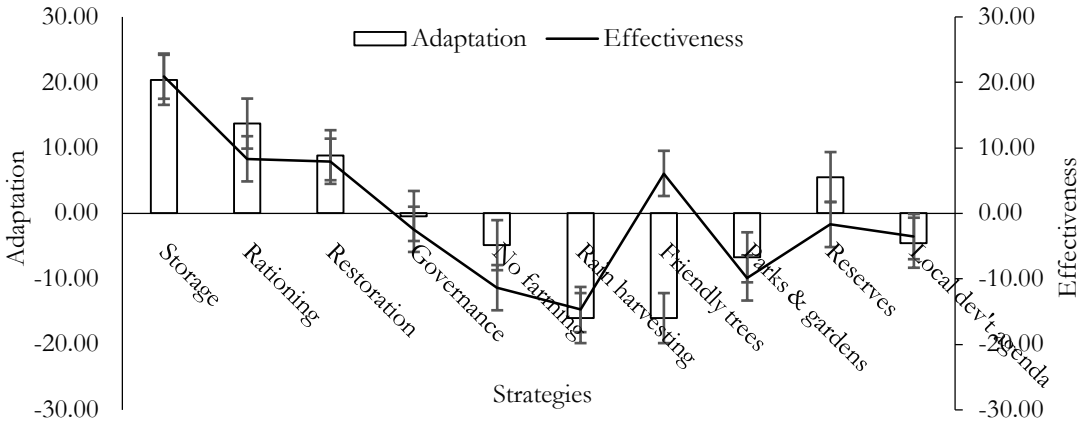


Figure 17: Adaptation to water scarcity and its effectiveness

These adaptation strategies are not very effective. Water governance, farming and grazing at watersheds, rain harvesting, parks and gardens, water reserves and factoring in water into the local development agenda are not effective. Some of this ineffectiveness in adaptation strategies are climate-related like prolonged dry seasons, unprotected watersheds, mismanagement of funds, and low representation of women in water governance, amongst others (Table 11).

Table 11: Limitations to adaptation to water scarcity in Bamenda III

Limitations	Yes		No		Don't know	
	F	%	F	%	F	%
Prolonged dry seasons	241	89.6	8	3.0	20	7.4
Incessant rationing	210	78.1	20	7.4	39	14.5
Unprotected watersheds	176	65.4	58	21.6	35	13.0
Mismanagement of funds	165	61.3	80	29.7	24	8.9
Inadequate storage facilities	126	46.8	85	31.6	58	21.6
Difficult topography	137	50.9	54	20.1	78	29.0
Conflicting water users	143	53.2	55	20.4	71	26.4
Poor maintenance of pipelines	194	72.1	35	13.0	40	14.9
Irregular payment of levies	159	59.1	66	24.5	44	16.4
Gender imbalances in water management	116	43.1	81	30.1	72	26.8
Farming at watersheds	176	65.4	62	23.0	31	11.5
Cattle rearing at watersheds	179	66.5	51	19.0	39	14.5
Bush fires	181	67.3	51	19.0	37	13.8
Average		63.0		20.2		16.8

Again, population increase against a backdrop of little or no efforts to improve water sources has been one of the key drivers of water scarcity in Bamenda III. Bamenda III has urban and semi-urban characteristics, with an influx of population in search of better opportunities through commercial ventures and education. Since 2016, the population has also increased by internally displaced people from hotspots of the crisis in the North West Region.

IV. Discussion

In the phase of so many problems plaguing water accessibility in the Bamenda III municipality, much needs to be done in terms of water governance, restoring water sources (watersheds) and many other strategies in the face of climate change. Water governance is the decision-making process through which water is managed (Norman *et al.,* 2010). Good governance involves adhering to principles of human rights, including effectiveness, responsiveness and accountability; openness and transparency; participation in the performance of key governance functions relating to policy and institutional arrangements; planning and coordination and regulation and licensing (Tume, 2021 b). For the integration of substance, integrated water resources management (IWRM) provides a process to involve stakeholders

across society, the economy and the environment. Greater public participation to manage climate risk is suggested as a way to build adaptive capacities at multiple levels, avoid institutional traps and prioritize risk reduction for socially vulnerable groups. At the same time, scientific information and data also need to be made available at the local level and included as information in local multi-stakeholder decision processes (Stewart *et al.,* 2020).

The 2021-2030 period has been declared as a decade of ecosystem restoration by the international community. At the local level of Bamenda III, much can be done from lowland wetlands to watersheds. Restoring wetlands and riverine areas can improve water quality by capturing pollutants and sediment from land degradation. In catchment areas, restoration can improve the flow and availability of water. Restoration of forests and other ecosystems has the potential to save an estimated USD 890 million each year in water treatment costs in the world's largest cities (United Nations Environment Programme-UNEP, 2021). To avoid catastrophic climate change, 2030 should mark two milestones: the end of the UN Decade on Ecosystem Restoration and the achievement of emissions reduction targets in line with the Paris Agreement goal to limit global warming to below 2°C. Delaying this will push humanity to pass a tipping point, beyond which solutions will be less effective and some damage, irreversible (IPCC, 2018). Improved land stewardship, including restoration, is one effective strategy to limit global warming (Strassburg *et al.,* 2020). Restoration is only part of the solution. Successfully achieving net-zero emissions will also rely on rapid emission reductions across all sectors worldwide. Without this multi-pronged effort, the benefits gained through restoration efforts may be only temporary.

Nature-based Solutions (NbS) can potentially contribute over one-third of the total climate change mitigation needed by 2030 to keep global warming to just below 2°C. NbS is inspired and supported by nature and uses, or imitates natural processes to contribute to the improved management of water (UN-Water, 2018). NbS can involve conserving or rehabilitating natural ecosystems and/or the enhancement or creation of natural processes in modified or artificial ecosystems like watersheds. Within nature-based solutions, the restoration of watersheds is a key element. This could involve action to better manage some 2.5 billion hectares of forest, crop and grazing land (restoration and avoided degradation), and restoring over 230 million hectares of natural cover (Griscom *et al.,* 2019). This is reflected in the evolution of themes for the celebration of World Water Day (Table 12).

Table 12: Evolution of Themes for World Water Day (2003-2022)

Years	Themes
2003	Water for people, water for life
2004-2006	Water, a shared responsibility
2007-2009	Water in a changing world
2010-2012	Managing water under uncertainty and risk
2013-2014	Water and energy
2015	Water for a sustainable world
2016	Water and jobs
2017	Wastewater: the untapped resource
2018	Nature-based solutions for water
2019	Leaving no one behind
2020	Water and climate change
2021	Valuing water
2022	Groundwater: Making the invisible visible

Source: UN-World Water Development Reports, 2003-2021

Humanity is altering the climate by continually emitting GHGs into the atmosphere is an inescapable reality (IPCC, 2014). Ecosystem and watershed restoration can play an important role in people's adaptation to climate change by increasing resilience and reducing vulnerability to extreme events. Restoration, conservation and sustainable management of biodiversity and ecosystem services can be included alongside more conventional approaches as part of an overall adaptation strategy (Kapos *et al.,* 2019). Ecosystem restoration inland can also reduce climate-related hazards, such as flooding, soil erosion and landslides linked to extreme rainfall events. Forest restoration on slopes reduces erosion that results from intense rainfall and enhances groundwater recharge.

Attention to NbS has significantly increased in recent years. This is evidenced through the mainstreaming of NbS into a wide range of policy advances, including in water resources, food and water security, biodiversity, environment, disaster risk reduction, urban settlements and climate change. This shows a growing convergence of interests around the recognition of the need for common objectives and the identification of mutually supporting actions such as the 2030 Agenda for Sustainable Development through its acknowledgement of the interdependency of its various

goals and targets. NBS mainly address water supply by managing precipitation, humidity, water storage, infiltration and transmission, so that improvements are made in the location, timing and quantity of water available for human needs.NBS for addressing water availability in urban settlements are also of great importance, given that the majority ofthe world's population is now living in cities.

An important sub-set of NbS is Ecosystem-based Adaptation (EbA), which helps people adapt to climate change. EbA is a nature-based approach that uses biodiversity and ecosystem services to help people adapt to the adverse effects of climate change (International Institute for Environment and Development-IIED, 2019). It involves activities such as water catchment restoration by tree planting, slope stabilization by tree planting to prevent landslides, applying integrated water resource management to address water shortages and managing forests sustainably to prevent erosion and regulate water flow. EbA rests on combining local knowledge with evolving information on climate change and has been applied to address the local challenges of climate change impacts.

V. Conclusion

Climate variability and change are already a reality in Bamenda III. Water catchments and sources are not properly harnessed. Water governance institutions are weak and inactive. There is a limited supply of pipe-borne water in communities and water-borne diseases are inevitable. Both climate and water management require mechanisms for oversight and coordination. Sectoral fragmentation and bureaucratic competition may pose serious challenges for the integration across scales. This calls for greater public participation to discuss and manage climate risk; build adaptive capacities at multiple levels, and prioritise risk reduction for socially vulnerable groups. Upscaling NbS and EbA are central to achieving the 2030Agenda for Sustainable Development. Sustainable water security will not be achieved through business-as-usual approaches. NbS work with nature instead of against it, and thereby provide an essential means to move beyond business-as-usual to escalate social, economic and hydrological efficiency gains in water resources management. NbS show particular promise in achieving progress towards sustainable food production, improved human settlements, access to water supply and sanitation services, and water-related disaster risk reduction. They can also help to respond to the impacts of climate change on water resources.

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Carbon Dioxide is Not the Guilty

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Abstract- Calculations show that the influence of the CO2 on the temperature is much less than one percent, negligible, therefore. The new water cycle, discovered by this author, is demonstrated physically and mathematically, showing the influence of certain human activities on the natural cycles and thus on the climate, that is, not as such influence been said to us up to now. The "science" on global warming would never discover the new water cycle, because it considers the atmosphere as a warming and monolithic body only as well as eliminates the water from the atmosphere. Climate events depend on temperature differences, not on a temperature alone. Global temperature differences make no sense. Global temperatures do not serve to explain climatic events, because these happen locally or regionally. In view of this, global temperatures of 1.0, 1.5 or 2.0 °C by 2100 or lower global temperatures than these ones for the current days do not cause floods, droughts, hot air at one side of the planet and a terribly cold at the opposite one, storms, tornadoes, hurricanes etc. Each one of these events has its own causes and consequences. Temperature differences are the driving force for the atmospheric events. If the water vapor in the atmosphere existed in the direct relation with the temperature, the Sahara would be the most humid place on Earth.

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Carbon Dioxide is Not the Guilty

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I. Introduction

Does anyone disagree that the planet is a big water box with a small part of land? I think that everybody agrees with this obvious reality, and that the physics must reflect such constitution and behavior. However, a group of people, who command the destinies of the humanity, thinks, for example, that a layer of CO2 is the main responsible and guilty for all extraordinary climate events of the planet. It was expected that such assumption came together with calculations that prove and justify mathematically such adoption, but there are not such proofs. Such thoughts and statements are based on imaginations, not on science.

In this paper, we can see how the planet and its atmosphere really work also showing calculations and demonstrations based on physical principles which show, for example, that the CO2 has a participation in the air temperature of much less than one percent, negligible, therefore. It is also shown the new water cycle, discovered by this author, who demonstrates it physically and mathematically. This new cycle shows the influence of certain human activities on the natural cycles and thus on the climate. Such human influence is not as has been said to us up to now. The "science" on global warming would never discover the new water cycle because it considers the atmosphere as a warming and monolithic body only as well as eliminates the water from the this gaseous layer. Also shown is the fact that climate events depend on temperature differences, not on a temperature alone. Global temperature differences make no sense. Global temperatures do not serve to explain climatic events, because these happen locally or regionally. In view of this, global temperatures of 1.0, 1.5 or 2.0°C by 2100 or lower global temperatures than these ones for the current days do not cause floods, droughts, hot air at one side of the planet and a terribly cold at the opposite one, storms, tornadoes, hurricanes etc. Each one of these events has its own causes and consequences. Temperature differences are the driving force for the atmospheric events. If the water vapor in the atmosphere existed in the direct relation with the air temperature, the Sahara would be the most humid place on Earth. .

II. How The Planet Really Works

a) The influence of CO2 on temperature

Being the planet a big water box with a small part of land it can be represented by Figure 1

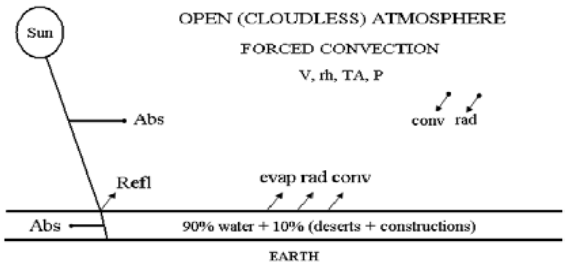

Fig. 1: Planet´s representation showing the Earth's surface and the atmosphere without cloud cover (open atmosphere)

When the sky is cloudy, the planet can be represented by Figure 2.

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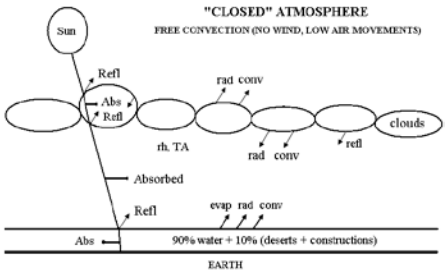

Fig. 2: Planet´s representation showing the Earth's surface and the atmosphere covered by clouds (closed atmosphere)

Both systems are very similar to an open evaporator and to a closed evaporator, respectively. The physical and mathematical demonstrations and comparisons of both systems are shown in Sartori (1996; 2019a). The land part do not appear in Figures 1 and 2. Figure 3 presents the well-known graph of the solar radiation wavelength spectrum with the absorption bands by different atmospheric gases. Figure 4 is an equivalent representation of Figure 3, but clearer and more didactic

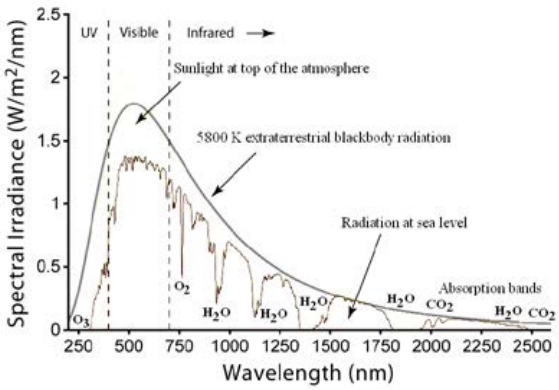

Fig. 3: Solar radiation spectrum with absorption bands by different atmospheric gases

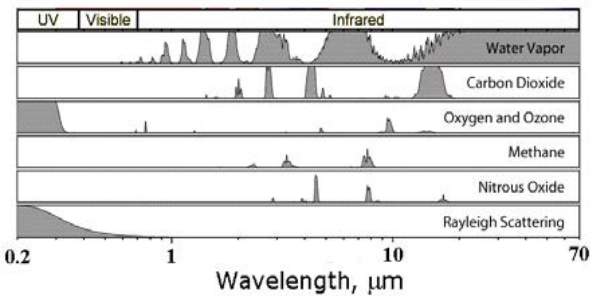

Fig. 4: Solar and IR radiation spectrums with absorption bands by different atmospheric gases (Wikipedia)

All of us know that the global warming literature attributes the air temperature mainly to a greenhouse effect caused by theCO2 and its radiation absorption. Such literature and corresponding verbal statements blame theCO2 for the planet´s temperature. However, this is equivocated because the air temperature is a consequence of many factors and not only of a gas, which participation in the atmosphere is of only 0.039 %, as well as the levels of CO2 are not identical around the globe. The air temperature is consequence of the heat and mass balances between the Earth´s surface and the air where the Sun´s heat, the heat and mass by evaporation, the heat and mass by sublimation from the glaciers, the heat by convection, conduction and radiation, the heat and mass by some human activities, greenhouse effect by cloud covers, the greenhouse effect by some gases included the water vapor should be considered. This is complex and cannot be reduced to a single gas. It is necessary to identify the processes. Such knowledge, among others, lead this author to discover the New Water Cycle in a few seconds, to discover new laws of evaporation, to create the general law of evaporation by Dalton-Sartori (see Sartori 2019b), to create an entire theory for the planet already confirmed by many experimental data from around the world, to create many important and accurate equations such as for evaporation and convection coefficient etc. There are more things between the sky and the Earth´s surface than the vane philosophy and "science" can imagine.

We can verify mathematically which is the contribution of the greenhouse effects by the four gases (water vapor, carbon dioxide, methane and nitrous oxide) considered by the literature on global warming. The physical properties that make a substance (glass, plastic, gases etc) to be or not to be of greenhouse effect is its concentration and its radiation absorption. So, Figures 3 and 4 show that the absorption of radiation by the water vapor is much greater than that of the CO2. It is known that its concentration is about 100 times greater than that of the CO2. In these graphs, we also see that the absorptions of radiation by the methane and nitrous oxide are negligible. We also know that the concentrations of the methane and nitrous oxide are insignificant. From these data, we verify that the water vapor is the gas of highest greenhouse effect and much higher than that of theCO2, but the literature on global warming neglect it due to its erroneous concept "*feedback*", which one also eliminates the water vapor from the atmosphere. Absurdity! The water vapor is always present in the atmosphere causing greenhouse effect, strong heat and mass transfer processes, floods, droughts and participates strongly in storms, tornadoes and hurricanes.

Admitting that the concentrations of the 4 gases that generate the highest greenhouse effects are, respectively, 45,000; 400; 1.8; 0.32 ppm and that they have the same radiation absorption, the greenhouse effect becomes dependent only on each gas concentration and thus a rule of three can be established to verify the influences that each gas would

have on the air temperature of 20 °C. The law of Beer-Lambert says that the radiation absorption per substance is directly proportional to the length L through which the ray crosses the substance and to its concentration c, i. e., AαLc. Therefore, considering L constant, this law also justifies the application of the rule of three. In this way we have

$$45000x20/45402.12 + 400x20/45402.12 + 1.8x20/45402.12 + 0.32x20/45402.12 = 20$$

$$19.823 + 0.176 + 0.000793 + 0.000141 = 20$$

That is, the percentage influence that each gas would have on the temperature is

$$H2O = 99{,}115\ \%;\ CO2 = 0{,}88\ \%;\ CH4 = 0{,}00397\ \%;\ N2O = 0{,}000705\ \%.$$

As we can see, the influence of theCO2 is less than one percent on the air temperature. At the same time, we observe the high contribution of the water vapor for the formation of the air temperature. Moreover, the influences of the methane and nitrous oxide are still much lower, that is, nothing. Furthermore, as in reality the radiation absorption of the other 3 gases are much lower than that of the water vapor, the percentages to be obtained are even much lower than those found above. Less than nothing! Additionally, as described above, it is not only a gas or 4 gases that compose or command the air temperature and then the participation of the greenhouse effect by the CO2 in the air temperature is still more negligible. Less than lessof nothing!

b) The New Water Cycle

All of us know that the planet has about 70% of water and 30% of land, but people should also to know that the land part is mostly covered by vegetation and that water also exists at the vegetation, humid soils, animals and glaciers. Therefore, we can consider that about 90% of the planet emit water by evaporation, because we can neglect only the constructions and deserts from this process (Sartori 2019b). Besides this, the vegetation and the animals evaporate through their leaves, trunks, branches and sides, which increase the area of evaporation in comparison to the flat area of the planet. This is a planet of evaporation.

The IPCC says that 99.99 % of the water vapor in the air have natural origin and thus no deindustrialization could change the amount of this gas in the atmosphere. Problem misunderstanding! Such misunderstanding clearly demonstrates the total lack of knowledge about the mass and heat behaviors of the atmosphere as well as about the nature of human activities. The atmosphere is not a monolithic block where only one factor at one side can cause all phenomena and consequences at the other side. On the contrary, the atmosphere is gaseous whose physical processes have multiple causes, variations and consequences. Such human activities humidify the planet, produce more clouds (or fewer clouds when the saturation limits of clouds for aerosols are reached, see Sartori 2012, 2015, 2019b), more precipitation (or less precipitation) and more floods in irregular amounts, times and places.

For example, the emissions of water vapor by nuclear and fossil fuel power plants, industries, vehicles, wildfires, burnings etc change the local or regional conditions of the atmosphere, directly. Moreover, the "science" on global warming considers the atmosphere as having only the role of warming and in its global panorama. As demonstrated in Sartori (2012, 2015, 2019a, 2019b) the H2O in the air also has human causes. In these publications, it is shown, among other things, that the water vapor in the air due to some human activities increases clouds, humidity, rain, floods etc., and modifies the natural cycles because they do this in higher amount, more rapid and more irregularly than the natural cycles can do. The traditional or natural water cycle and the new water cycles are mass balances! As the new water cycle clearly shows, it is not a matter of changing completely the atmosphere, but to modify partially locally or regionally something in the atmosphere. The IPCC sees only the CO2, its greenhouse effect, its radiation and a global temperature, and thinks that all of this is everything and homogeneous or uniform globally.

The natural water cycle became known as Precipitation = Evaporation, but this equation needs a correction to include the sublimation from glaciers, and thus we have Precipitation = Evaporation + Sublimation. The new water cycle is not related to this correction; instead, it is related to the interference of certain human activities on the climate as seen below.

If I throw a drop of water into the atmosphere, one drop of water will come back and this equation must be modified to

$$Precipitation = Evaporation + Sublimation + One\ drop \quad (1)$$

Of course, one drop does not matter, but only one fossil fuel power plant of 600 MW emits to the air more than 50 million liters per day of water in form of vapor. Imagine the billions of fossil fuel and nuclear power plants, industries, vehicles, burnings, wildfires etc., that throw into the atmosphere at least millions of tons of water and aerosols, and much heat in every instant around the world and faster and more irregularly than the natural cycles can do. These are just the factors that form clouds and affect hydrological and other natural cycles and thus the climate. A nuclear power

plant throws into the atmosphere about 70 % more water than a fossil fuel power plant.

The new water cycle also shows that the issue is not to change completely, but to modify something partially. Such human actions humidify the planet, produce more clouds (or fewer clouds when the saturation limits of clouds for aerosols are reached, see Sartori 2012; 2015, 2019a, 2019b), more precipitation (or less precipitation) and more floods in irregular amounts, times and places. The strong heats and masses emitted by such human sources also cause atmospheric instability, being that storms, tornadoes and hurricanes happen only when the atmosphere is unstable.

We can make the water mass balance for the new water cycle as follows. For a control volume of the Earth´s surface we have

$$dM_{w,s}/d\theta = dM_p/d\theta - dM_{ev}/d\theta - dM_{su}/d\theta - dM_h/d\theta$$

which means

Variation of accumulation of water mass (in the bodies of water, soils, vegetation and animl) = variation of water mass in (precipitation) – variation of water mass out (evaporation) – variation of water mass out (sublimation) – variation of water mass out (human activities).

where M_h = water mass emitted by human activities

The water mass balance of the new water cycle is completed when we make the mass balance for a selected layer (control volume) of the atmosphere

$$dM_{w,a}/d\theta = dM_{ev}/d\theta + dM_{su}/d\theta + dM_h/d\theta - dM_p/d\theta$$

which means

Variation of accumulation of water mass (clouds + water vapor) = variation of the water mass in (evaporation) + variation of the water mass in (sublimation) + variation of the water mass in (human activities) – variation of the water mass out (precipitation), θ is time.

As we can see, everything is a matter of variation. The "science" on global warming would never discover the new water cycle because it considers the atmosphere as a warming and a monolithic body only as well as eliminates the water from the atmosphere.

c) The global temperature

The global temperature has been used for many purposes such as to make alarmism about the warming of the planet due to a negligible temperature of 2.0°C for 2100, to try to explain climatic events, to try to justify the greenhouse effect of the CO2 etc. However, we should reason.

In a world that grows in population and in services it is obvious that with the current technology, it needs more industrialization including power plants, and consequently more emissions of gases and heat, thus warming the places locally or regionally, directly. That is, before to activate a greenhouse effect, the emissions heat the air around and thermometers in the vicinity record such new temperature of the air.

An air temperature obtained globally does not serve to explain climatic events, because these happen locally or regionally. A man with the head into a freezer and the feet into an oven has an average temperature of 36,5°C, normal, therefore. If statistics were physics. That is, a global temperature does not explain local conditions. Moreover, it must be known that what generates atmospheric events is the *temperature difference,* not the temperature itself.

In the nature, the events happen from the less probable situation to the most probable situation, i. e., from the high pressure to the lower pressure. The special fact is that pressure is function of temperature, thus a pressure difference (P1 – P2) is equivalent to the temperature difference (t^1 – t2). The temperature difference is the driving force for the evaporation, wind, rain, convection, conduction, radiation exchange, storms, tornadoes, hurricanes etc. These events happen locally or regionally. A global temperature difference makes no sense and a global temperature has a limited importance.

An excellent example that explains the high influence of local temperature differences on climate events is the following, explained for the first time in the world. Always when there is a great wildfire, we see the reporters invariably saying something like this: "The strong winds prevent or make difficult the fire combat". It is not because appeared a fire and due to a bad luck appeared the strong winds, too. No! The explanation is that the fire heats strongly the air, this creates a great temperature difference in relation to the air of the vicinity and this generates strong air streams, that is, strong winds. This also shows that the atmospheric events are local or regional.

Calculations performed by this author show that for 230°C the wind speed is 180 km/h, for 360°C the wind speed is 276 km/h and for 30°C the wind speed is 34 km/h. While the first and second cases correspond to speeds of hurricanes, the third one only moves the leaves of small trees.

The wind results from a horizontal air pressure difference, and since the pressure is function of the temperature, the wind is function of temperature differences. Since the Sun heats different parts of the Earth differently, this causes pressure differences and then the Sun is the force that generates the local winds. Fossil fuel power plants emit gases at 1,000-2,000°C and we can understand that this affects the local or regional winds.

In view of this, global temperatures of 1.0, 1.5 or 2.0°C by 2100 or lower global temperatures than these

ones for the current days do not cause floods, droughts, hot air at one side of the planet and a terribly cold at the opposite one, storms, tornadoes, hurricanes etc. Each one of these events has its own causes and consequences. For example, the heat waves that reach Europe are due to African winds, not due to a greenhouse effect of the CO2.

d) Erroneous understanding about evaporation

The "science" on global warming makes lots of scientific insanities, being another one the absurd belief that increasing the air temperature the evaporation increases.

The fact that a nonprofessional person believes that higher air temperatures produce higher evaporation is acceptable, but that an entire science believes the same and as one of its most relevant and fundamental principles is unacceptable. In summer, the evaporation is higher because the Sun heats more the water being that evaporation is an exponential function of the water temperature while increasing the air temperature decreases the relative humidity, thus increasing the evaporation. However, the increase of the air temperature alone decreases the evaporation.

We can see in almost all corresponding equations that the evaporation is directly proportional to the pressure difference and thus to the temperature difference between the water surface and the air. See, for example, the Sartori equation for evaporation (Sartori, 2019a; 2019b)

$$E = 0.0041V^{0.8}L^{-0.2}(P_W - P_d)/P$$

where E = evaporation, kg/m^{2}s; V = wind speed, m/s; L = length of water surface in the wind direction, m; P_d, P_W=partial pressures of the water vapor at the dew point temperature, at the water surface temperature, respectively, Pascal; P = atmospheric pressure, Pascal.

However, many important institutions and followers repeat the referred error and blame the carbon dioxide. See, for example, the NOAA (2017) statement: "the warmer air caused by the global warming increases the evaporation". Still, (NASA 2017a, b): "When the concentration of carbon dioxide increases, more water evaporates, which then amplifies the greenhouse warming and then the CO2is the gas that forms the temperature and the size of the greenhouse effect". Moreover, "The amount of water vapor in the atmosphere exists in the direct relation of the temperature. If you increase the air temperature, more water evaporates and this one becomes vapor and vice-versa. Thus, when some extra thing causes an increase of the temperature (such as extra CO2) more water evaporates. Then, as the water vapor is a greenhouse gas, this additional water vapor makes the temperature to increase still more, a positive feedback. (Skeptical Science). If the water vapor in the atmosphere existed in the direct relation with the temperature, the Sahara would be the most humid place on Earth! When the premise is wrong, the conclusions are also wrong, that is, the CO2 is not the gas that forms the temperature and the size of the greenhouse effect. This "science" makes confusion between the capacity of the warm air to contain more humidity with the capacity of evaporation, due to lack of knowledge on evaporation. See Sartori (2019b) for a more complete analysis about the subject.

Also, see Sartori (2019b) for a demonstration on how hurricanes form with extremely high pressures and extremely high amounts of water vapor, together with high temperatures, which ones are reached only by direct human actions on the air, becoming evident the influence of these human activities on the generation of these phenomena. Meanwhile, such literature thinks that the CO2 and a negligible temperature of 2.0°C indirectly and for 2100 not having the proper physical properties are the guilty of everything nowadays.

III. Conclusion

In this paper, we see how the planet and its atmosphere really work regarding climate events. Also shown are the calculations and physical demonstrations that theCO2 has a participation in the air temperature of much less than one percent, negligible, therefore. It is also shown the new water cycle, discovered by this author, who demonstrates it physically and mathematically. This new cycle evidences the influence of certain human activities on the natural cycles and thus on the climate, that is, not as such influence has been said to us up to now. The "science" on global warming would never discover the new water cycle because such "science" considers the atmosphere as a warming and monolithic body only as well as eliminates the water from this gaseous layer. Also shown is the fact that climate events depend on temperature differences, not on a temperature itself. Global temperature differences make no sense. Global temperatures do not serve to explain climatic events, because these happen locally or regionally. In view of this, global temperatures of 1.0, 1.5 or 2.0°C by 2100 or lower global temperatures than these ones for the current days do not cause floods, droughts, hot air at one side of the planet and a terribly cold at the opposite one, storms, tornadoes, hurricanes etc. Each one of these events has its own causes and consequences. Temperature differences are the driving force for the atmospheric events. If the water vapor in the atmosphere existed in the direct relation with the air temperature, the Sahara would be the most humid place on Earth.

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Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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