Guns, Bombs, and Pollution: Unraveling the Nexus between Warfare, Terrorism, and Ecological Devastation in Iraq

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Iraq's environment has experienced significant pollution and degradation, earning it the dubious distinction of being one of the most polluted and degraded regions globally, according to the Globe Pollution Review. The past three decades of armed conflict have exacted a heavy toll on the country, resulting in widespread human suffering, including countless fatalities, injuries, and a massive displacement of people. Amidst this death and destruction, the ecosystem has also endured severe damage, and its decline carries long-lasting implications.

The environmental crisis in Iraq has been worsened by the presence of extremist groups such as the Islamic State (ISIS) and various militia groups. These groups have compounded the damage already caused by the protracted conflict in the country. Everywhere ISIS has operated, significant environmental degradation has occurred, posing severe health risks to the local population.

A qualitative approach, including a review of relevant literature and analysis of case studies, will be used to explore the environmental consequences of armed conflicts, militia activities, and oil industry operations in Iraq. The study will also examine the long-term health risks associated with environmental degradation caused by intense urban combat.

The study reveals that a combination of factors, including bomb remnants, extremist group activities, and oil industry pollution, has led to Iraq's environmental devastation. As a result of the conflict, oil and gas facilities have transformed into significant sources of health and environmental hazards. Furthermore, urban combat involving airstrikes, VBIEDs, and artillery has created long-lasting ecological and health hazards due to the destruction of industrial sites and critical infrastructures in densely populated areas.

This research paper highlights the intricate relationship between war, terrorism, and the environment in Iraq. It sheds light on the destructive effects of armed conflict on the ecosystem and emphasizes the urgent need for comprehensive environmental remediation efforts. Through a comprehensive analysis of available literature, this research explores the direct and indirect ecological consequences of armed conflicts and acts of terrorism in Iraq. Addressing the pollution and ecological devastation will not only contribute to the well-being of the Iraqi people but also foster long-term stability and sustainable development in the country.

Keywords: Iraq, environment, conflict, terrorism, oil and gas, pollution, war

Impact of Wars and Conflict on Environmental Pollution: An Overview
Throughout history, the environment has all too often fallen victim to the devastating effects of political conflict. From ancient times, military strategies have involved deliberately destroying the natural surroundings of adversaries. The practice of burning and salting lands was employed as a means to cripple opponents and render their territories uninhabitable. As technology advanced, the destructive capacity of warfare increased exponentially, leading to more severe and widespread environmental damage. An impactful illustration of this phenomenon is the utilization of Agent Orange, an herbicide, by the United States during the Vietnam War, leading to the widespread
devastation of extensive forests and agricultural lands. Such acts of ecological devastation have solidified the concept of "scorched earth" as a grim reality deeply ingrained in the annals of violent conflict (Stellman et al., 2003).

Iraq, a country burdened by numerous wars, protracted civil strife, and a long-lasting embargo, has experienced significant deterioration in its land, air, water, and healthcare infrastructure. The cumulative impact of these events, compounded by the war on terrorism, has resulted in a multitude of environmental and health challenges. Two notable concerns that have emerged among these challenges include the widespread presence of harmful compounds in the form of light dust particles, leading to pervasive dust storms, and the contamination of the food chain with depleted uranium (DU). Furthermore, the Al-Tuwaitha nuclear research complex, devastated during the Gulf War in 1991, has experienced substantial radioactive contamination due to the removal of radioactive materials and sources during the 2003 war. This research aims to explore the environmental and health consequences stemming from conflicts and contamination in Iraq, with a particular focus on the impact of military actions, the distribution of depleted uranium, and the radioactive contamination of the Al-Tuwaitha nuclear research complex.

For the past three decades, Iraq has faced the catastrophic aftermath of armed conflicts, leaving behind a distressing legacy of loss of life and widespread devastation. The toll of these conflicts is immeasurable, with hundreds of thousands of lives lost and countless more individuals suffering from injuries and trauma. The impact on Iraq's physical landscape has been profound, as cities and towns lie in ruins, bearing witness to the relentless devastation. Not only have these conflicts caused extensive damage to infrastructure and critical facilities, but they have also ravaged agricultural lands and forests, stripping away the country's natural resources. The industrial areas, once vibrant centers of economic activity, now stand as polluted hotspots, posing serious environmental and health risks to the population. The healthcare system, already strained by the conflicts, has been further crippled, leaving communities in desperate need of vital medical support. Moreover, the institutional capacity for governance and oversight, including the ability to manage industrial and environmental concerns, has suffered significant setbacks.

The country is grappling with a multitude of environmental issues stemming from a combination of factors, including the cumulative impact of military operations and the utilization of various conventional and non-conventional weapons. The country's environment has suffered extensive damage as a result of the Second Gulf War in 1991, followed by the war in 2003, which witnessed the deployment of internationally prohibited weapons. The consequences of these invasions are starkly manifested in the pollution of soil, air, and water resources, exacerbating the environmental challenges faced by Iraq. The detrimental effects extend beyond the environment, leading to severe human health consequences, economic repercussions, and risks to agricultural production and future generations. The pollution of the Iraqi environment not only poses immediate health risks to the population but also has long-term implications that will require sustained efforts to address.

The 2003 US occupation of Iraq and the subsequent rise of ISIS and other extremist groups unleashed a wave of violence and destruction across the country. Urban areas bore the brunt of the intense fighting, with cities and towns left in ruins and critical infrastructure reduced to rubble. As ISIS faced defeat and retreat, they resorted to scorching earth tactics, intentionally destroying natural resources such as oil wells, agricultural fields, and water sources. This deliberate devastation not only inflicted immediate economic losses but also left behind a toxic legacy with potential long-lasting environmental and health repercussions. The destruction of oil infrastructure
resulted in massive oil spills and pollution, further exacerbating the environmental crisis. Additionally, the use of unconventional weapons and explosives contaminated soil and water, posing significant health risks to affected populations.

During the invasion of Iraq in 2003, the United States and its allies employed radioactive and toxic weapons as a means to weaken Iraq's military capabilities and exert control over its population. These weapons, including depleted uranium (DU) munitions, were strategically utilized with the aim of exhausting Iraq's strength and diminishing its capacity to resist the invasion (Al-Azzawi, 2006).

During the 2003 invasion of Iraq, the use of DU rounds by armies was widespread, even in densely populated areas like Baghdad, Samawa, Fallujah, Diyala, Najaf, Salahuddin, Basra, Nasiriya, and others. The extensive and repeated utilization of DU, which had already been employed after the Gulf War in 1991, led to a substantial expansion of DU-contaminated regions (Al-Azzawi, 2006). As a result, the civilian population residing in these previously affected areas faced additional exposure to radiation in the aftermath of the 2003 invasion. This unfortunate circumstance resulted in hundreds of thousands of Iraqis being subjected to higher levels of radioactivity compared to the normal background levels. The consequences of this extended exposure to DU and increased radioactivity have had a profound impact on the affected communities (Al-Bayati et al., 2013).

The use of radioactive and toxic weapons during warfare raises significant concerns regarding both the ecosystem and human health. Depleted uranium munitions are highly effective in penetrating armored targets due to their dense composition and pyrophoric properties. However, upon impact, DU projectiles release aerosolized particles that can contaminate the air, soil, and water, thereby posing ongoing risks to both the local population and the invading forces.

The multifaceted impact of wars, embargo, civil strife, and the war on terrorism has severely affected Iraq's environmental and health infrastructure. Pollution from military actions, characterized by the transformation of desert sands into light dust particles, has resulted in pervasive dust storms across the country. Moreover, the existence of depleted uranium in the food chain has raised concerns regarding the health risks faced by the population. The radioactive contamination of the Al-Tuwaitha nuclear research complex and its surroundings further amplifies the environmental and health challenges confronted by Iraq.

As a consequence of these events, the term 'environmental terrorism' has become entrenched within the academic sphere. This concept has not gone unnoticed in academic circles, where it has sparked considerable interest. Scholars have put forth arguments asserting that Saddam Hussein's actions can indeed be classified as 'environmental terrorism' (Lanier-Graham, 1993; Winnefeld, 1994). Moreover, a number of articles published in major law journals across North American universities have sought to establish a legal framework for indicting acts of 'environmental terrorism.'1 These discussions have shed light on the potential implications of 'environmental terrorism' as a risk to global security.

Scholars have coined the term "environmental terrorism" to address the intentional destruction of the environment (Schwartz, 1998). For an act to be considered environmental terrorism, it must meet two criteria: first, it must violate national and international laws related to environmental disruption in peacetime or wartime; and second, it must exhibit the essential characteristics of terrorism, such as specific objectives and violence directed towards a symbolic target. The term "environmental terrorism" is specifically applicable when two criteria are met: firstly, the
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perpetrator utilizes the environment as a genuine symbol, invoking fear in the larger population regarding the ecological consequences of their actions (Schwartz, 1998). Environmental terrorism refers to acts of violence, destruction, or sabotage deliberately targeted at the environment with the intent to create fear, disrupt societies, and advance political, ideological, or socio-economic goals. It involves the use of threats of force to inflict harm on natural resources, ecosystems, and human populations that rely on them.

Environmental terrorism can take various forms, including the deliberate pollution of air, water, or soil; destruction of critical infrastructure such as oil fields, industrial facilities, or energy installations; illegal wildlife trafficking; deforestation; and attacks on environmental activists or conservationists. The motivations behind environmental terrorism can vary widely, ranging from ideological or political beliefs to economic interests, such as controlling resources or influencing policy decisions. Perpetrators may include extremist groups, individuals, or even state actors.

While there is a substantial body of scholarly work exploring the potential role of environmental change as a driver of conflict, there is relatively limited research on how conflict itself can lead to environmental change (Homer-Dixon, 1991, 1994). This gap in understanding hinders a comprehensive assessment of the complex association between conflict and the environment.

Cities at the heart of conflict
Throughout the protracted conflict in Iraq, cities have been thrust into the forefront, bearing the brunt of intense sieges, relentless airstrikes, and devastating assaults involving Vehicle Borne Improvised Explosive Devices (VBIEDs) and artillery. These urban environments, once vibrant and bustling, have witnessed the harrowing spectacle of entire neighborhoods and industrial areas being leveled. Among these cities, Mosul has garnered significant attention, owing to its status as one of Iraq's most populous urban centers prior to its capture by ISIS. However, the repercussions of combat in such densely populated areas extend far beyond the immediate destruction and loss of life (PAX, 2017). They give rise to long-term environmental and health risks that continue to haunt the affected communities. The scars of war manifest in contaminated soil, water sources tainted by hazardous substances, and the release of toxic pollutants into the air, posing significant challenges to the well-being and future resilience of these urban landscapes.

Environmental Consequences of Military Actions
Over the past three decades, Iraq has faced numerous conflicts, with the 1991 Gulf War standing out as particularly devastating. This war inflicted significant damage on Iraq's infrastructure, impacting both military and civilian targets. Plants, buildings, bridges, and clinics bore the brunt of destruction. Notably, the use of DU weapons by the allied forces marked a historic first, with more than 300 tons deployed in the western parts of Basrah City. This extensive use of DU weaponry had far-reaching consequences for the affected area and its inhabitants, contributing to long-term environmental and health concerns (Al-Azzawi, 2006).

Following the January 1991 Gulf War Coalition air campaign, deliberate actions by Iraqi forces led to the occurrence of two significant oil spills in the Gulf waters. Subsequently, under the orders of Saddam Hussein, approximately 1250 oil wells were detonated, leading to the ignition of nearly 600 wells. The resulting massive fires generated dense smoke, transforming daytime conditions into a darkened atmosphere reminiscent of nighttime in Kuwait (Popkin, 1991). The occurrence of these events elicited a strong international response and led to the accusation by the US government that Iraq had engaged in acts of 'environmental terrorism' (Schwartz, 1998).
deliberate actions taken by Iraqi forces, including the oil spills and the intentional ignition of oil wells, generated widespread condemnation and intensified concerns about the environmental effect of the conflict.

The frequent military engagements in Iraq have inflicted significant damage to its natural environment, exacerbating the degradation of land, air, and water resources. Military operations often involve explosive munitions and heavy machinery that break up desert sands, transforming them into fine dust particles. These particles are subsequently carried by winds, resulting in widespread dust storms that impact nearly every city in Iraq. Such dust storms not only reduce visibility and impair air quality but also transport harmful compounds that can pose severe health risks to the population.

During the 1991 retreat of the Iraqi Army from Kuwait, they inflicted extensive damage on oil infrastructure, including oil wells, storage tanks, and factories. This resulted in the distribution of vast volumes of oil and the ignition of numerous fires (Hobbs & Radke, 1992). Moreover, Iraqi forces intentionally uncapped or damaged wells, leading to the uncontrolled flow of crude oil across the landscape. These actions resulted in the death of numerous animals and caused significant pollution, with over 706 kilometers (439 miles) of the Saudi Arabian coastline being affected by oil contamination. The deliberate destruction and mismanagement of oil resources during the conflict had severe and lasting ecological consequences for the Iraqi environment (Bulmer, 2018).

Air pollution is characterized by the presence of harmful substances in the air, posing risks to various living organisms and public assets. It manifests through noticeable signs like discolored and hazy air or unpleasant odors (De Nevers, 2010). This environmental issue arises from both human activities and natural sources, leading to the accumulation of hazardous chemicals in the atmosphere (Pan & Wang, 2014). In the context of conflict, such as war and terrorism, air pollution can intensify due to increased emissions from activities like burning of fossil fuels, destruction of infrastructure, and release of hazardous substances.

Iraq bears the burden of a distressing environmental legacy resulting from previous conflicts. The aftermath of these conflicts has left a trail of environmental pollution, with hazardous materials spreading due to the devastation of industrial and martial targets. Moreover, the government's capacity to efficiently examine and manage contaminated sites has been severely undermined. The widespread destruction of infrastructure, coupled with the influx of Syrian refugees and internally displaced persons (IDPs), has further exacerbated the pollution challenges faced by Iraq. A matter of significant concern revolves around the historical utilization of weapons containing depleted uranium (DU), renowned for their radioactive and toxic characteristics. During the wars in 1991 and 2003, the US and the UK deployed DU ammunition, with over 1,100 locations targeted, including densely populated areas. The lasting consequences of DU on both human health and the environment have raised alarm among communities and medical experts alike. Addressing and mitigating these environmental hazards is a critical task that requires concerted efforts, including comprehensive monitoring, remediation, and support for affected communities to alleviate the burdens imposed by this enduring environmental crisis.  

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The presence of toxic substances in sand particles within Iraq is attributed to the historical pollution resulting from military activities that have disrupted desert sands, transforming them into fine dust particles. These dust particles are carried by dust storms, affecting numerous cities across Iraq (Sultan et al., 2012). Notably, in the city of Baghdad, sandstorms have been identified as carrying trace amounts of uranium, which can have collective effects on the environment and human health (Al-Dabbas & Khafaji, 2012). In heavily bombarded Iraqi cities like Basrah and Fallujah, there is well-documented evidence of significant metal contamination, which has been connected to the concerning occurrence of congenital birth defects in the country. The metals identified include lead (Pb), mercury (Hg), and uranium, with the latter being present in relatively low concentrations (Al-Sabbak et al., 2012). Conversely, areas in the northern region of Iraq, which were not directly involved in conflicts subsequent to the Iraq-Iran War, have shown minimal environmental contamination (Al-Ani & Mohammed, 2009).

The Impact of Terrorism on the Environment

In the last few decades, terrorism has emerged as a significant cause of environmental pollution, with its impact steadily increasing. The Global Terrorism Index (GTI) has identified Iraq as the most affected state by terrorism for the years 2016, 2017, and 2018, highlighting the severe consequences of terrorist activities on both human lives and the environment (Bildirici & Gokmenoglu, 2020). Iraq's struggle with terrorism has resulted in widespread destruction, including the contamination of natural resources and ecosystems. Following closely behind are countries like Afghanistan and Nigeria, which also experience significant environmental damage due to acts of terrorism. The detrimental effects of terrorism on the environment not only disrupt ecological balance but also pose long-lasting challenges for the affected regions in terms of environmental sustainability and restoration.

Terrorism's impact extends beyond its immediate economic and social ramifications, affecting the environment as well. The environmental damages resulting from acts of terrorism are wide-ranging, encompassing not only the destruction caused by terrestrial conflicts but also the adverse effects of terrorist camps and bases. These locations often witness activities that lead to deforestation, pollution, and habitat destruction. Additionally, the energy consumption associated with sustaining such operations contributes to carbon dioxide emissions (CO2) and exacerbates climate change. The environmental toll of terrorism is not limited to a single aspect but encompasses a complex web of interconnected issues that warrant attention and mitigation.

Terrorist attacks can have far-reaching consequences on economic growth, particularly through multiple channels, including a notable decline in tourism revenues and foreign direct investments (FDI). Acts of terrorism create an atmosphere of fear and uncertainty, deterring tourists and investors from visiting or investing in affected regions. Moreover, terrorist attacks often result in the destruction of critical infrastructure, further hindering economic development. Rebuilding infrastructure and ensuring security measures increase the cost of doing business, diverting resources from productive sectors of the economy. The reallocation of resources towards counterterrorism efforts reduces the capacity for investments in environmental sustainability and renewable energy (Bildirici & Gokmenoglu, 2020).

Despite the increasing occurrence of terrorist attacks globally, there is a lack of comprehensive studies focusing on the specific effects of terrorism on environmental pollution and resource consumption. Understanding these dynamics is crucial for designing effective policies that address
both the economic and environmental dimensions of terrorism, promoting resilience and sustainable development in the face of such threats.

The environmental impact of terrorism extends far beyond carbon dioxide emissions. In their pursuit of mass destruction weapons, terrorists often employ a wide array of chemicals and heavy metals, including iron, copper, and DU. These substances contain toxic elements, which poses substantial risks to both the environment and human health. When released into the environment, these heavy metals contaminate soil, air, and water sources, leading to long-term pollution that is difficult to purify or remediate effectively. The persistence of these pollutants can have severe consequences for ecosystems, as well as for the well-being of local populations, as they can bioaccumulate in the food chain and cause chronic health issues (Bildirici & Gokmenoglu, 2020). Recognizing the level of the environmental pollution caused by terrorism is crucial for developing strategies to address and mitigate its harmful effects, safeguarding both the environment and human welfare.

Islamic State (ISIS) inflicted significant damage to the environment during its reign of terror. The group's destructive actions can be categorized as a form of environmental terrorism. ISIS engaged in deliberate and systematic destruction of natural resources and ecosystems in the territories under its control. They engaged in practices such as oil smuggling and illegal excavation of archaeological sites, causing irreversible damage to the environment. Additionally, ISIS engaged in devastating tactics, setting oil wells on fire, and contaminating water sources, leading to severe pollution and ecological devastation. These destructive acts not only caused immediate harm to the environment but also had long-term consequences for the affected regions, undermining the livelihoods of local communities and exacerbating the already dire environmental challenges in the area.

ISIS recognized the strategic importance of oil in advancing its insurgency and realizing its vision of establishing a caliphate. ISIS considered oil as a crucial resource to sustain its operations, finance its activities, and exert influence over neighboring regions. The Shura council within ISIS acknowledged that control over oil reserves was vital for the survival of the insurgency and the funding of their ambitions. This strategic oil-focused approach was formulated well in advance, even predating their territorial expansion into Iraq's Mosul. By taking control of oil fields in their occupied territories, ISIS gained access to significant crude production, estimated to be around 34,000-40,000 barrels per day. The militants capitalized on this resource, selling the oil directly at the wellhead for prices ranging from $20 to $45 per barrel, which generated substantial daily revenue averaging $1.5 million. This oil strategy became a fundamental pillar for ISIS, enabling them to sustain their war machine, provide essential services such as electricity, and exert economic leverage in pursuit of their ideological objectives (Solomon & Chazan, 2015).

Environmental and Health Risks of Oil Fires
The conflicts in Iraq have had a devastating impact on the oil and gas industry, transforming once productive facilities into significant sources of health and environmental hazards. Various militant groups and local communities seeking economic gains have started targeting refineries, storage tanks, pipelines, and oil fields for exploitation. In an effort to cripple the revenue streams of ISIS, the US-led coalition conducted airstrikes specifically aimed at the oil industry, with hundreds of oil trucks being targeted. While these strikes aimed to undermine the financial capabilities of extremist groups, they also unintentionally contributed to the destruction of infrastructure and the
release of pollutants into the environment. This dual consequence has further compounded the toll on public health and the already fragile ecosystem in Iraq (Iraq Oil Report, 2016).

The oil and gas industry in Iraq has suffered severe damage during the conflicts, resulting in significant environmental and public health consequences. During the territorial recovery operations by Iraqi forces against ISIS, the group employed desperate scorched earth tactics, intentionally igniting oil wells. This merciless action caused devastating oil spills, rampant fires, and thick plumes of smoke, resulting in extensive damage to the surrounding ecosystems and communities (PAX, 2017). Compounded by the loss of functional oil facilities, both ISIS and affected communities resorted to makeshift methods of oil refining, further exacerbating the environmental and health hazards. This dire situation not only poses immediate risks but also leaves a long-lasting legacy of contamination and ecological damage.

The Qayyarah oil field, one of Iraq's significant oil reserves, fell into the hands of ISIS during the conflicts (see Figure 1). The capture of this strategic site had dire consequences for both the environment and the local population. Analysis of satellite imagery conducted by UNOSAT revealed a harrowing reality: a large number of fires engulfing the oil field were releasing thick plumes of smoke that not only polluted the air but also deposited harmful soot over Qayyarah and the vast surrounding area. Astonishingly, some of these fires raged for an astonishing nine months, continuously emitting toxic residues and exacerbating the severity of the environmental crisis. The result of black soot blanketed the cities and land, casting a grim shadow over the region.3 The long-lasting effects of these fires, both in terms of air pollution and land contamination, demand urgent attention and remediation efforts to alleviate the hazardous conditions faced by the local communities and restore the environmental integrity of the area.

Figure 1: The image depicts the Qayyara oil field with a fire raging in the foreground. Photo by Kate Geraghty (Bulmer, 2018).
The Alas and Ajeel oil fields, located in the rugged terrain of the Hamrin mountains, became another grim example of the destructive tactics employed by ISIS (Figure 2). After capturing the Alas field in 2014, the group engaged in a protracted fight with Iraqi forces for control over the area. During their retreat, ISIS resorted to setting the oil wells ablaze on multiple occasions, leaving a trail of destruction in their wake (Iraq Oil Report, 2017). These deliberate acts of arson were aimed at inflicting further harm and hindering the advancing Iraqi forces. The latest instance of this scorched earth tactic occurred in late 2017, as ISIS retreated and set numerous wells on fire. Satellite images from the European Space Agency (ESA) captured the alarming sight of dark plumes of smoke rising intermittently from the Alas oil field, a visual testament to the ongoing environmental and economic devastation caused by these destructive acts. From August 2015 to November 2017, the region was marred by the continuous release of toxic smoke, perpetuating the cycle of environmental degradation and harm inflicted upon the surrounding communities.4

Pipelines, crucial lifelines for the transportation of oil, have frequently become prime targets during the conflicts in Iraq, resulting in devastating spills when breached. The Iraqi-Turkish Pipeline (ITP), the primary conduit for Iraqi oil exports to Turkey, endured a relentless onslaught, with an average of one bombing per week in 2013 alone. The consequences of such attacks were dire. In 2014, a pipeline near the Tigris River fell victim to a bombing, causing a massive 70-kilometer-long oil slick to pollute the water. In an effort to mitigate the chemicals in the water, the decision was made to set the oil ablaze, leading to the generation of black clouds and a continued haze. To ensure the safety of downstream populations along the Tigris River, a warning was issued advising against the use of tap water for a period of three days. Additionally, cities such as Baghdad took precautionary measures by temporarily discontinuing their water supply from the Tigris until the oil slick had dissipated.5 These incidents underscore the grave environmental consequences
resulting from the deliberate targeting of pipelines, which not only disrupt the flow of vital resources but also jeopardize the well-being of communities and ecosystems that depend on them.

Oil fires, such as those ignited during conflicts in Iraq, unleash a barrage of harmful substances into the air (UNEP, 1999), posing significant dangers to both human wellbeing and the environment. These fires release a toxic cocktail of pollutants, including sulphur dioxide, carbon monoxide, and metals like nickel, vanadium, and lead. The emission of nitrogen and sulphur combinations contributes to the formation of acid rain, which affects plants and lead to soil acidification. Additionally, these noxious ingredients can initiate critical immediate health effects, particularly for individuals with pre-existing respiratory conditions. The inhalation of these pollutants can trigger respiratory distress, exacerbate asthma symptoms, and increase the risk of respiratory infections (Joint UNEP, 2016).

**Depleted Uranium (DU) Contamination in the Food Chain**

According to various studies, the utilization of Depleted Uranium (DU) munitions has been documented in Iraq, starting from the first Gulf War in 1991. It is estimated that a substantial amount of DU, ranging between 320 to 800 tons (see Figure 3), was predominantly employed during the engagement with the retreating Iraqi forces from Kuwait towards the northern region of Basra City (Al-Azzawi, 2006).

![Figure 3: Aerial view captures bombed 'Highway of Death' with destroyed Iraqi vehicles near Kuwait City during Operation Desert Storm in 1991 (Williams, 2002).](image-url)
During the 2003 US-led war in Iraq, both the United States and United Kingdom governments acknowledged the utilization of depleted uranium (DU) munitions in Iraq, with an estimated usage of at least 150 tons of such ammunition (Fathi et al., 2013). Uranium, a naturally occurring radioactive element, finds applications in the atomic energy industry, and DU is the byproduct resulting from its use. In military operations, DU is employed for the production of highly potent projectiles, such as bullets. When these projectiles penetrate their targets, they release DU dust into the surrounding environment, comprising uranium oxides that can be inadvertently ingested or inhaled. Multiple reports have indicated the presence of DU in various locations across Iraq. The presence of DU in soil raises concerns about its potential accumulation in the food chain and subsequent ingestion by humans.

DU is a chemically lethal and dangerous heavy metal that is primarily generated as a waste product by the nuclear power industry. Its exceptional hardness makes it a valuable material for military applications, particularly in the production of armor-piercing ammunition (Al-Azzawi, 2006). DU possesses unique properties that enable projectiles to effectively penetrate armored targets. As a heavy metal, DU poses chemical hazards that can have detrimental impacts on human health and the environment. Exposure to DU has been linked to various adverse health effects, including potential damage to the kidneys, lungs, and reproductive system. Moreover, DU is radioactive, emitting alpha particles as it undergoes radioactive decay. This radioactivity presents additional risks, especially when DU particles are dispersed in the environment following the impact of DU-containing projectiles. Such dispersal can lead to the contamination of soil, water, and air, thereby presenting a long-term risk to ecosystems and human populations in affected areas (Miller, 2009).

The incidence of various health issues, such as childhood leukemia, congenital malformations, and breast cancer, has seen a multi-fold increase. Particularly concerning is the shifting trend of leukemia cases towards younger children in recent years, with a clear correlation to the geographical distribution of contaminated areas. This serves as compelling evidence linking the exposure to low-level radiation and the resulting health damage (Yaqoub et al., 1998).

An extensive analysis conducted between 1990 and 1997 revealed alarming trends in pediatric leukemia and overall harmful incidents among children under the age of 15. The findings depicted a significant surge, with a staggering 60% increase in children's leukemia and a striking 120% rise in all malignant cases during this period. Furthermore, the study shed light on a notable shift in the age distribution of leukemia cases. In 1990, children under the age of 5 accounted for only 13% of the total cases. However, by 1997, this age group constituted a substantial 41% of the overall leukemia cases, indicating a noteworthy inclination towards younger children (Yaqoub et al., 1998b).

Several additional studies have highlighted alarming trends in various types of cancers in Basra. Between 1990 and 1997, there was a significant surge in reported cases of uterine cancer, witnessing a staggering 160% increase. Similarly, thyroid cancer cases experienced a notable rise of 143% during the same period. Furthermore, breast cancer cases recorded a substantial 102% increase, while lymphomas showed an 82% rise in 1997 compared to 1990 (Yaqoub et al., 1998). In a study conducted by Iraqi researchers (Al-Jobori, 2013), it was discovered that cancer patients in the middle and south of Iraq had DU concentrations in their tissues, bones, and blood. The collected specimens from these war-affected areas exhibited significant contamination with depleted uranium, surpassing international standards. Notably, all the examined samples displayed higher levels of depleted uranium compared to noncancerous diseases. These findings shed light
on the concerning impact of DU exposure on the health of individuals residing in regions affected by war.

Numerous scholars have extensively studied the impacts of metal pollution on ecosystems, revealing a range of indirect consequences that can have longer-lasting effects than direct impacts. Metal pollution can disrupt the delicate balance of ecosystems, affecting various organisms and their habitats. It might lead to changes in biodiversity, impair reproductive capabilities, and hinder the growth and development of plants and animals. Moreover, the continuous release of emissions resulting from oil consumption and various chemical substances can exert long-lasting and wide-ranging impacts on the environment. These emissions contribute to air pollution, leading to respiratory problems, ecological imbalances, and climate change. The long-term consequences of these pollutants can be profound, affecting not only the immediate vicinity but also distant regions through atmospheric transport and deposition.⁶

These findings point to a concerning change in the prevalence of major diseases in Basra. By 1997, the leading types of cancer in the region were identified as breast, lymphomas, uterine, and skin cancers, indicating a change in the distribution of prevalent malignancies compared to earlier records.

The deployment of DU munitions in Iraq has been a persistent phenomenon since 1991, with successive generations of DU-assisted Tomahawk arsenal and Bunker Buster Bombs being employed (Williams, 2002). These weapons were utilized during the 1990s within the designated No-Fly Zones, encompassing the northern parts of Iraq. Furthermore, the 1998 attack on Iraq witnessed the continued utilization of DU ordnance (Figure 4). The bombing campaigns involving DU munitions persisted throughout Iraq's military operations in 2003, as well as in places that resisted the invasion of Iraq (Zwijnenburg & Weir, 2016).
The enduring usage of DU ammunition on Iraqi soil represents an ongoing concern, marked by the recurrent involvement of advanced military technologies incorporating DU components. This protracted deployment occurred not only in the context of the No-Fly Zones, but also during significant military campaigns and periods of occupation. These actions have raised academic and scholarly interest due to the likely health and environmental consequences associated with the utilization of DU munitions over an extended period in Iraq.

The presence of DU in the Iraqi food chain is a concerning issue that warrants rigorous investigation. Studies have revealed measurable concentrations of uranium in animal organs across various Iraqi cities, with the highest levels observed in the southern regions. The ingestion of food contaminated with depleted uranium raises significant health concerns, as it has been associated with various adverse effects, including radiation-related illnesses and long-term genetic damage.

In summary, the use of DU during the invasion and subsequent military operations in Iraq significantly expanded the areas contaminated by radioactive materials. This has had severe consequences for the Iraqi population, with a notable rise in radiation-related illnesses such as childhood leukemia and congenital malformations. The correlation between exposure to low-level radiation and the observed health damages is strongly supported by the geographical distribution of contaminated areas and the shifting incidence rates of leukemia among younger children.
Radioactive Contamination of the Al-Tuwaitha Nuclear Research Complex

A significant contributor to pollution in Iraq was the Al-Tuwaitha nuclear research site, with particular focus on the Nuclear Reactor Tammuz-2 (Figure 5). Situated approximately 20 km southeast of Baghdad in the Tigris valley, this area has endured significant environmental degradation (Al-Taii et al., 2012). During the Gulf War in 1991, the nuclear research reactors situated at the Al-Tuwaitha site were destroyed. However, the situation worsened in the 2003 Iraqi war when containers comprising radioactive materials and sources were looted from the site (Rasheed, 2013). Consequently, a substantial amount of radioactive pollution occurred, affecting not only the site itself but also its surrounding areas (Al-Atabi, 2008). Soil samples obtained from the vicinity of Al-Tuwaitha revealed contamination with Cs-137 and Co-60, indicating the presence of hazardous radioactive elements (Al-Bakhat et al., 2012; Zaboon et al., 2014).

Figure 5: The nuclear reactor Tammuz-2 at the Al-Tuwaitha nuclear research site was destroyed (Al-Shammari, 2016).

Water Systems in Peril

The relentless fighting and neglect of essential maintenance in Iraq have put critical water systems at high risk of damage, exacerbating the already dire situation faced by affected communities. Notably, Fallujah, Mosul, and the Haditha Dam have suffered significant threats. However, the gravity of the situation goes beyond mere neglect, as the extremist group ISIS intentionally targeted water infrastructure, viewing the environment as a weapon of war. Deliberate acts of sabotage included damaging dams, hydroelectric power plants, and barrages, with devastating consequences.

As an illustration, ISIS employed tactics such as flooding specific areas to hinder the movement of ground forces and deliberately cut off water supplies to other regions (UN Environment, 2017). In their retreat, they systematically destroyed bridges, blocking canals, and dismantled pumping stations, crippling entire communities by denying them of water and electricity produced by dams (Schwartzstein, 2017). Additionally, the group contaminated water sources directly, inflicting further harm on already vulnerable populations. Shockingly, the Tigris River, a lifeline for many, was used as a mass grave, with ISIS callously dumping over 100 bodies into its waters. Furthermore, the deliberate poisoning of ponds, canals, and streams with oil products and poisonous waste added to the catastrophic environmental impact. The group resorted to poisoning wells by disposing diesel fuel into them, making the water toxic for humans, plants, and livestock.
The consequences of such actions are far-reaching, placing immense strain on local communities' access to clean water and decimating agricultural livelihoods. Adding to the already dire situation, the firing of vast quantities of munitions in urban areas has not only caused explosive destruction but also poses potential long-term health and environmental risks. As Iraq struggles to rebuild, addressing the devastating effects on water systems and ensuring access to safe and clean water for its people must be a top priority. The restoration of water infrastructure, remediation of contamination, and provision of support to affected communities are crucial steps towards healing and securing a sustainable future for Iraq.

**Discussion and conclusion**

This research paper provides a comprehensive examination of the environmental consequences of armed conflicts, militia activities, and oil industry operations in Iraq. It highlights the intricate relationship between war, terrorism, and the environment, emphasizing the urgent need for comprehensive environmental remediation efforts in the country.

One of the key findings of the study is that the past three decades of armed conflict in Iraq have resulted in significant environmental degradation and pollution. The presence of extremist groups such as ISIS and various militia groups has further worsened the environmental crisis. The activities of these groups, coupled with the protracted conflict, have caused severe damage to the ecosystem, posing health risks to the local population.

The research identifies several factors contributing to Iraq's environmental devastation. Bomb remnants, extremist group activities, and oil industry pollution have a significant position in the degradation of the environment. The conflict has transformed oil and gas industry facilities into significant contributors to health and environmental hazards. Additionally, urban combat involving airstrikes, VBIEDs, and artillery has resulted in the destruction of industrial sites and critical infrastructures in densely populated areas, leading to long-lasting ecological and health hazards.

Another crucial aspect highlighted in the research is the presence of harmful compounds and substances in Iraq's environment. Light dust particles, which contribute to pervasive dust storms, have become a prevalent issue, affecting air quality and human health. Furthermore, the presence of DU in the food chain is a significant concern. The utilization of various conventional and non-conventional weapons, including explosive munitions and heavy machinery, has exacerbated the deprivation of land, air, and water resources.

The study also points out the role of terrorism in environmental pollution. Iraq has been identified as the most affected country by terrorism, and the consequences extend beyond human lives to the environment. Terrorist activities lead to the contamination of natural resources and ecosystems, disrupting ecological balance and posing long-lasting challenges for environmental sustainability and restoration.

In conclusion, Iraq's environment has been severely impacted by armed conflicts, militia activities, and the operations of the oil industry. The research paper highlights the multifaceted factors contributing to the environmental crisis in Iraq, including bomb remnants, extremist group activities, oil industry pollution, and the utilization of various weapons.

The study emphasizes the urgent need for comprehensive environmental remediation efforts in Iraq. Addressing the pollution and ecological devastation is crucial not only for the well-being of the Iraqi people but also for fostering lasting stability and sustainable development in the country.
To mitigate the environmental consequences, it is imperative to focus on several key areas. Firstly, efforts should be made to clean up contaminated sites, including oil and gas facilities, and restore critical infrastructures in urban areas. Secondly, measures should be taken to reduce pollution from the oil industry, such as implementing stricter regulations and promoting cleaner technologies. Thirdly, there is a need for increased awareness and education regarding the health risks associated with environmental degradation, particularly in relation to dust storms and the presence of hazardous substances.

International cooperation and support are essential in addressing the environmental crisis in Iraq. The international community should provide technical expertise, funding, and resources to facilitate environmental remediation efforts. Collaborative initiatives involving governments, NGOs, and local communities are crucial for implementing sustainable solutions and restoring the ecological balance.

By taking proactive measures to restore and protect the environment, Iraq can pave the way for a more sustainable future. Investing in environmental remediation will not only contribute to the well-being of the Iraqi people but also lay the foundation for long-term stability, resilience, and sustainable development in the country.

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Endnotes


Guns, Bombs, and Pollution: 
Unraveling the Nexus between Warfare, Terrorism, and Ecological Devastation in Iraq

References


