Original Research Article
ISSN: 3041-5357
Journal homepage: https://diversity.researchfloor.org/

Journal of Diversity Studies

Environmental and Public Health Risks Associated with Household Cesspits in the Gaza Strip, Palestine, under Israel's Ongoing War of Genocide and Ethnic Cleansing (2023–2026)

Abdel Fattah N. Abd Rabou*[1], Ilham S. Abu Shaheen[2], Heba I. Baraka[3], Ghadeer I. Baraka[4], Othman A. Abd Rabou[4], Rajaa E. Salha[5], Rana, M. Jouda[6], Rana H. Idais[7], Mazen S. Al-Banna[7], Azhar A. Tanboura[8], Asmaa A. Abd Rabou[9], Bassam A. Tayeh[9], Mazen T. Abualtayef[9], Fahid K. Rabah[9], Hala R. Al-Harazeen[10], Ramy A Abu Alajeen[10], Mahmoud I. Elhabiby[11], Mohammed R. Al-Agha[12], and Maged M. Yassin[13]

[1]*Department of Biology and Biotechnology, Faculty of Science, Islamic University of Gaza, P.O. Box 108, Gaza Strip, Palestine*
[2]*Program of Crisis and Disaster Management, Islamic University of Gaza, Gaza Strip, Palestine*
[3]*Department of Nursing and Health Sciences, University College of Applied Sciences (UCAS), Gaza Strip, Palestine*
[4]*Department of Journalism and Media, Faculty of Arts, Islamic University of Gaza, Gaza Strip, Palestine*
[5]*Director General of the Palestinian Press and Media Network, Gaza Strip, Palestine*
[6]*Department of Public Relations and Media, Faculty of Media and Information Technology, University of Palestine, Gaza Strip, Palestine*
[7]*Water & Environment Quality Authority, Gaza Strip, Palestine*
[8]*Department of Public Relations, Municipality of Beit Lahia, North Gaza Governorate, Gaza Strip, Palestine*
[9]*Department of Civil Engineering, Faculty of Engineering, Islamic University of Gaza, Gaza Strip, Palestine*
[10]*Department of Geography, Faculty of Arts, Al-Aqsa University, Gaza Strip, Palestine*
[11]*Department of Medical Laboratory Sciences, Faculty of Medical Sciences, Al-Aqsa University, Gaza Strip, Palestine*
[12]*Department of Environment & Earth Sciences, Faculty of Science, Islamic University of Gaza, Gaza Strip, Palestine*
[13]*Faculty of Medicine, Islamic University of Gaza, Gaza Strip, Palestine*

ABSTRACT

Household cesspits have long served as an important onsite sanitation option in non-sewered areas of the Gaza Strip, Palestine. Since October 2023, however, the widespread destruction of wastewater infrastructure and municipal services, combined with mass displacement and overcrowding, has transformed their use into a major environmental and public health concern. This descriptive study assessed cesspit-related risks during Israel's ongoing war of genocide and ethnic cleansing (2023–2026) by integrating field observations, photographic and documentary evidence, peer-reviewed literature, and official, humanitarian, media, and verified social-media sources. Before the war, approximately 14.6% of housing units—an estimated 60,000–65,000 households—relied on cesspits or holding pits. During the war, approximately 320,000 informal emergency cesspits were reportedly constructed in displacement areas, frequently without lining, engineering supervision, adequate separation from groundwater, or reliable emptying services. Field evidence documented overflowing pits, sewage accumulation around shelters, contamination of streets and agricultural land, offensive odors, insect and rodent proliferation, and unsafe manual excavation. The principal environmental risks include the potential infiltration of fecal microorganisms, nitrate, nutrients, household chemicals, and other wastewater-derived contaminants into soils and the already degraded Gaza Coastal Aquifer, as well as pollutant transport toward agricultural and coastal ecosystems. Associated public health concerns include direct exposure to untreated wastewater, heightened risks of enteric and intestinal parasitic infections, skin disorders, food contamination, vector-related nuisance and pathogen transmission, and occupational injury. Because no systematic laboratory or epidemiological measurements were possible, these findings demonstrate plausible and substantial risk pathways rather than quantified contamination or disease causation. Immediate priorities include safe temporary sanitation, restoration of septage collection and wastewater services, protection of groundwater and food-production areas, and systematic environmental, epidemiological, and occupational-health monitoring. Long-term recovery requires resilient, safely managed sanitation systems that reduce dependence on unregulated cesspits and protect Gaza's vulnerable population and ecosystems.

Keywords: *Household Cesspits; Sanitation; Wastewater Infrastructure; Coastal Aquifer; Environmental Contamination; Public Health; Displacement Camps; Israel's Ongoing War of Genocide and Ethnic Cleansing (2023–2026); Gaza Strip; Palestine.*

Citation: Abdel Fattah N. Abd Rabou, Ilham S. Abu Shaheen, Heba I. Baraka, Ghadeer I. Baraka, Othman A. Abd Rabou, Rajaa E. Salha, Rana M. Jouda, Rana H. Idais, Mazen S. Al-Banna, Azhar A. Tanboura, Asmaa A. Abd Rabou, Bassam A. Tayeh, Mazen T. Abualtayef, Fahid K. Rabah, Hala R. Al-Harazeen, Ramy A. Abu Alajeen, Mahmoud I. Elhabiby, Mohammed R. Al-Agha, and Maged M. Yassin [2026]. Environmental and Public Health Risks Associated with Household Cesspits in the Gaza Strip, Palestine, under Israel's Ongoing War of Genocide and Ethnic Cleansing (2023–2026). *Journal of Diversity Studies.* **DOI: https://doi.org/10.51470/JOD.2026.5.2.199**

Corresponding Author: *Abdel Fattah N. Abd Rabou*

E-mail Address: *arabou@iugaza.edu.ps*

Article History: *Received 09 May 2026 | Revised 10 June 2026 | Accepted 11 July 2026 | Available Online August 07, 2026*

1. INTRODUCTION

Safe sanitation is fundamental to protecting public health, preventing environmental contamination, and supporting the sustainable management of water resources. Inadequate management of domestic wastewater remains a major source of environmental pollution and disease transmission, particularly in densely populated and resource-limited settings [1]. These challenges become substantially more severe during brutal wars, when damage to water and sanitation infrastructure, disruption of essential services, and large-scale population displacement compromise wastewater management and create serious environmental and public health hazards [2] [3].

In areas lacking centralized sewerage networks, household cesspits (also referred to as cesspools or onsite wastewater storage pits) are widely used for the collection and temporary storage of untreated domestic wastewater (Figure 1) [4] [5]. Unlike septic systems, cesspits provide little or no wastewater treatment and therefore function primarily as storage facilities. Their environmental safety depends on appropriate design, construction, maintenance, and regular emptying. Poorly designed or overloaded cesspits can release untreated wastewater into surrounding soils and shallow aquifers, resulting in contamination by nutrients, pathogens, organic matter, and other pollutants [6]-[10]. Leakage and overflow also promote the proliferation of disease vectors, generate offensive odors and hazardous gases, and increase environmental and occupational health risks, particularly in densely populated communities relying on vulnerable groundwater resources [1] [11].

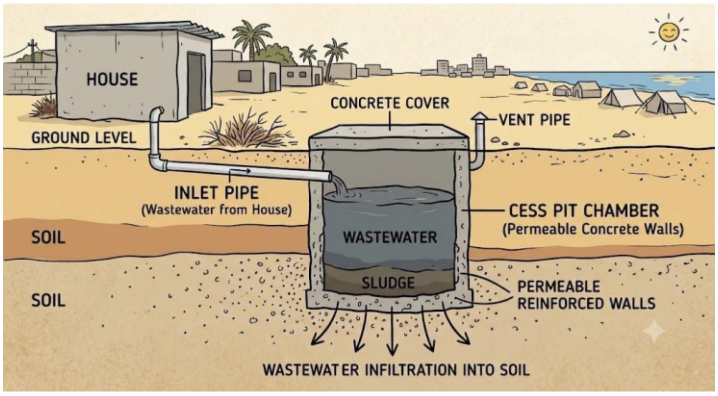

Figure 1: AI-generated conceptual schematic of a household cesspit system, illustrating its basic structure and function for the collection and temporary storage of untreated domestic wastewater in areas without centralized sewerage networks

The Gaza Strip represents one of the world's most environmentally vulnerable and densely populated coastal regions. Its limited area (approximately 365 km^2), rapid population growth, chronic water scarcity, and almost complete dependence on the Gaza Coastal Aquifer have created longstanding challenges for sustainable water and sanitation management [12]-[18]. Numerous studies have reported elevated nitrate concentrations, microbial contamination, and declining groundwater quality throughout the Gaza Strip, identifying household cesspits and poorly managed sanitation facilities as important diffuse sources of groundwater pollution [14] [15] [19] [20].

Historically, wastewater management in the Gaza Strip has been constrained by incomplete sewerage coverage, insufficient infrastructure capacity, chronic electricity shortages, financial limitations, and rapid urban expansion [21] [22]. Consequently, many households—particularly those located beyond the coverage of centralized sewerage networks—have relied on household cesspits for decades as their primary means of onsite domestic wastewater management. Palestinian census data and field-based research confirm that cesspits remain an important sanitation option in communities lacking access to centralized sewerage infrastructure [9] [23]. Previous studies in Palestine further demonstrated that poorly designed or inadequately maintained cesspits continuously release untreated wastewater containing fecal microorganisms, nitrogen compounds, and other contaminants, thereby contributing to groundwater pollution and broader environmental degradation [24]-[27].

The environmental implications of dependence on household cesspits are intensified by the Gaza Strip's exceptionally high population density, the shallow and vulnerable nature of the Gaza Coastal Aquifer, and the population's continued reliance on groundwater despite its severe and long-standing quality deterioration [13] [23] [28]. Groundwater contamination by nitrate and pathogenic microorganisms remains a major environmental health concern because the Gaza Coastal Aquifer continues to represent the principal freshwater resource for domestic use. Recent investigations have identified significant health risks associated with exposure to contaminated groundwater, including nitrate-related disorders and microbial infections [29]. In addition, wastewater pollution has been associated with the persistence of waterborne diseases, parasitic infections, and other sanitation-related illnesses affecting vulnerable communities throughout the Gaza Strip [30]-[32].

These pre-existing sanitation challenges have been dramatically intensified by Israel's ongoing war of genocide and ethnic cleansing against the Gaza Strip since October 2023. Extensive destruction of wastewater treatment plants, sewerage networks, pumping stations, electricity systems, water supply facilities, and municipal infrastructure has severely disrupted wastewater collection, treatment, and disposal. These impacts have been compounded by widespread destruction of residential areas, large-scale population displacement, and the establishment of overcrowded displacement camps with severely inadequate sanitation facilities. Similar consequences have been documented in other armed conflicts, where damage to water and sanitation infrastructure has accelerated environmental degradation, compromised water quality, and increased the risk of infectious disease transmission [3]. In the Gaza Strip, the collapse of essential WASH services has resulted in uncontrolled wastewater discharge and increasing contamination risks affecting terrestrial, groundwater, and coastal environments [33].

Under these unprecedented conditions, household cesspits have evolved from a chronic sanitation limitation into a major environmental and public health emergency. The destruction of sewerage systems, prolonged electricity shortages, and the urgent need for emergency sanitation have substantially increased reliance on household cesspits, particularly within displacement camps and heavily damaged residential areas. Many of these emergency cesspits have been excavated rapidly without appropriate engineering standards or environmental safeguards, increasing the likelihood of wastewater leakage, overflow, and direct infiltration into surrounding soils and the shallow Gaza Coastal Aquifer.

A recent systematic review confirmed that poorly designed onsite sanitation systems constitute important diffuse sources of groundwater contamination, especially in densely populated regions characterized by shallow groundwater conditions [10].
The environmental impacts of widespread dependence on emergency household cesspits extend beyond localized wastewater disposal. Continuous leakage of untreated sewage contributes to groundwater contamination, nutrient enrichment, agricultural soil degradation, and deterioration of terrestrial and coastal ecosystems. Nutrients, pathogens, pharmaceuticals, and other contaminants originating from onsite sanitation systems may persist within soils and migrate into groundwater, thereby threatening ecosystem integrity and water security [10]. Previous investigations in the Gaza Strip similarly demonstrated that untreated wastewater contributes to microbial contamination, nutrient loading, and chemical pollution affecting both terrestrial and marine ecosystems [16] [34]-[36]. Consequently, the interaction between damaged sanitation infrastructure and increased reliance on emergency cesspits is expected to accelerate environmental degradation and hinder future ecosystem recovery.
The deterioration of sanitation conditions also represents a serious public health concern. Overflowing cesspits and untreated wastewater increase opportunities for human exposure to pathogenic bacteria, viruses, protozoa, and helminths through direct contact, contaminated soils, groundwater infiltration, and mechanical transmission by insects and rodents. These risks are amplified in overcrowded displacement camps where access to safe drinking water, hygiene facilities, and healthcare services is severely limited. Similar relationships between armed conflict, deteriorating WASH conditions, and increased incidence of diarrheal diseases have recently been reported in conflict-affected populations in Ethiopia [37]. Furthermore, recent investigations in the Gaza Strip demonstrated that widespread destruction of WASH infrastructure has substantially increased environmental and public health risks associated with inadequate sanitation and wastewater contamination [38]. Children, older adults, pregnant women, and immunocompromised individuals remain particularly vulnerable to sanitationrelated diseases under these humanitarian conditions.
Beyond the immediate environmental and health impacts, continued dependence on household cesspits may generate long-term consequences for environmental recovery and sustainable water resource management. Progressive contamination of the Gaza Coastal Aquifer threatens the sustainability of Gaza's principal freshwater resource, while persistent nutrient enrichment, microbial pollution, and soil degradation may impair agricultural productivity and ecosystem resilience for years after the cessation of hostilities. Comparable long-term impacts of armed conflicts on water resources and ecosystem integrity have been documented elsewhere, demonstrating that damage to water and sanitation infrastructure frequently produces environmental consequences extending well beyond the conflict period [3] [39]. Accordingly, the interaction between sanitation failure, groundwater vulnerability, ecosystem degradation, and public health represents one of the most critical environmental challenges facing post-war recovery in the Gaza Strip.
Despite extensive research on wastewater management, groundwater contamination, and environmental pollution in Palestine, limited attention has been devoted to evaluating household cesspits as a distinct environmental and public health hazard under conditions of prolonged brutal wars, mass displacement, and widespread infrastructure collapse. Previous investigations primarily examined groundwater quality, conventional wastewater pollution, or onsite sanitation under relatively stable environmental conditions [14] [15] [20] [25]-[27], whereas no comprehensive study has specifically assessed the unprecedented expansion of emergency household cesspits and their associated environmental and public health risks during the ongoing war. Addressing this knowledge gap is essential for developing evidence-based strategies that support emergency sanitation interventions, environmental restoration, and longterm public health protection.
Therefore, this study aims to comprehensively assess the environmental and public health risks associated with household cesspits in the Gaza Strip, Palestine, under Israel's ongoing war of genocide and ethnic cleansing (2023–2026). Specifically, the study evaluates how the destruction of sanitation infrastructure and mass population displacement have increased dependence on emergency household cesspits, examines their potential impacts on groundwater quality, soils, agricultural land, and surrounding ecosystems, and investigates the associated risks of pathogen transmission, vector proliferation, and sanitation-related diseases. By integrating field observations, photographic documentation, peer-reviewed literature, and official environmental and humanitarian data, this study provides one of the first comprehensive assessments of household cesspits as an emerging environmental and public health emergency under wartime conditions. The findings are expected to strengthen scientific understanding of sanitation-related vulnerabilities during brutal wars and provide an evidence-based foundation for environmental restoration, sustainable wastewater management, emergency sanitation planning, and public health protection in the Gaza Strip.

2. METHODOLOGY

2.1. Study Area

The Gaza Strip is a narrow coastal region along the southeastern Mediterranean coast of
Palestine, covering approximately 365 km^2 and inhabited by more than 2.4 million people (Figure 2). The region relies almost entirely on the Gaza Coastal Aquifer for domestic water supply, which has been severely degraded by over-abstraction, seawater intrusion, agricultural activities, and wastewater contamination. Limited sewerage coverage, rapid population growth, and recurrent damage to sanitation infrastructure have resulted in widespread dependence on onsite sanitation systems, particularly household cesspits and cesspools, as alternatives to centralized wastewater networks [9] [14] [15] [40]. Since October 2023, Israel's ongoing war of genocide and ethnic cleansing has caused unprecedented destruction of water and sanitation infrastructure, further increasing reliance on damaged and overloaded cesspits and substantially elevating environmental and public health risks.

Figure 2: Geographical location of the Gaza Strip, Palestine, on the southeastern coast of the Mediterranean Sea

2.2. Study Design and Data Collection

This study employed a descriptive environmental and public health assessment to evaluate the environmental and health risks associated with household cesspits in the Gaza Strip during Israel's ongoing war of genocide and ethnic cleansing (2023–2026). The assessment integrated multiple complementary sources of evidence, including field observations, photographic documentation, scientific literature, and information obtained from official reports, humanitarian agencies, reliable media outlets, and verified social media platforms. This multi-source approach was adopted because the ongoing war severely disrupted routine environmental monitoring and restricted access to many affected areas. Repeated field visits were conducted whenever security conditions permitted to document the condition of household cesspits, wastewater overflows, sewage accumulation, damage to sanitation infrastructure, and visible environmental impacts in residential and displaced communities. Field observations were supported by systematic photographic documentation collected during site visits and supplemented, where necessary, by images from reliable public sources to verify sanitation deterioration and wastewater-related environmental conditions.

2.3. Literature Review and Secondary Information

A comprehensive review of peer-reviewed articles, academic theses, technical reports, and publications from governmental and international organizations was undertaken to establish the scientific background for the study. The review focused on onsite sanitation systems, cesspit performance, groundwater contamination, wastewater management, environmental pollution, and associated public health risks in Palestine and comparable regions. Additional information on sanitation emergencies, infrastructure destruction, wastewater incidents, and humanitarian conditions was obtained from official reports, humanitarian organizations, reputable media outlets, and verified social media sources to complement field observations where direct access was not feasible.

2.4. Data Analysis

Data obtained from field observations, photographic records, scientific literature, and secondary information sources were synthesized using a qualitative descriptive approach. The analysis focused on identifying evidence of wastewater leakage, cesspit overflow, groundwater contamination, deterioration of sanitation services, exposure pathways to microbial and chemical contaminants, and the resulting environmental and public health impacts associated with the widespread failure of onsite sanitation systems during Israel's ongoing war of genocide and ethnic cleansing (2023–2026).

3. RESULTS

3.1. Current Status of Household Cesspits in the Gaza Strip

Before October 2023, household cesspits constituted an important component of decentralized sanitation systems in the Gaza Strip, particularly in rural, peri-urban, and marginalized communities lacking reliable access to centralized sewerage networks. Their widespread use reflected rapid population growth, high population density, limited expansion of sewerage infrastructure, and prolonged restrictions on infrastructure development. According to the Palestinian Central Bureau of Statistics [23], approximately 14.6% of housing units relied on cesspits or holding pits rather than public sewerage networks, representing an estimated 60,000–65,000 household systems. Most cesspits consisted of unlined or partially lined underground pits designed to collect domestic wastewater while allowing partial infiltration into surrounding soils, with accumulated wastewater periodically removed by vacuum tankers. However, inadequate engineering design, insufficient lining, limited storage capacity, and poor separation from groundwater resources rendered many systems susceptible to leakage, seepage, and overflow, posing chronic environmental and public health concerns.

Following the widespread destruction of sanitation infrastructure during the ongoing war, updated official statistics on operational household cesspits are unavailable. Nevertheless, the collapse of sewerage networks, wastewater pumping stations, and treatment facilities, together with the rapid expansion of displacement camps, has markedly increased dependence on emergency onsite sanitation systems. Recent reports indicate the construction of approximately 320,000 informal cesspits in displacement areas [41], most of which are unlined and lack basic engineering standards, thereby increasing the likelihood of wastewater leakage, environmental contamination, and human exposure to untreated sewage.

3.2. Collapse of Sanitation Infrastructure and Increased Dependence on Household Cesspits

The destruction of wastewater infrastructure fundamentally altered sanitation practices throughout the Gaza Strip. Damage to wastewater treatment plants, pumping stations, sewerage networks, and municipal service facilities severely reduced the capacity of centralized wastewater management systems, forcing households and displacement camps to rely increasingly on existing cesspits and improvised sanitation facilities. Simultaneously, prolonged electricity outages, fuel shortages, restricted access for maintenance teams, and damage to municipal service vehicles disrupted routine cesspit emptying and maintenance operations. As population displacement intensified, many temporary shelters were established in areas lacking adequate sanitation infrastructure. Existing cesspits rapidly exceeded their storage capacity because of increased wastewater generation, while additional emergency pits were excavated to meet urgent sanitation needs.

In many locations, the absence of functional wastewater collection and disposal systems resulted in wastewater accumulation, uncontrolled discharge, and deteriorating environmental conditions within residential neighborhoods and displacement camps. Collectively, these observations demonstrate that the collapse of centralized sanitation infrastructure substantially increased dependence on household cesspits and intensified sanitation-related environmental and public health risks.

3.3. Types and Construction Practices of Household Cesspits in Gaza Displacement Camps

Field observations identified four principal types of household cesspits used in displacement camps across the Gaza Strip. Their construction varied according to local soil conditions, groundwater depth, availability of construction materials, and the urgent need to establish emergency sanitation facilities.

3.3.1. Unlined Soil Excavation Pits

Unlined excavation pits represented the simplest and most rapidly constructed sanitation systems in temporary displacement areas (**Figure 3**). These pits were excavated directly into natural soils, particularly sandy and sandy-calcareous (kurkar) formations, allowing partial infiltration of wastewater into surrounding soil layers. In areas characterized by clay-rich soils or shallow groundwater tables, however, infiltration capacity was limited, resulting in rapid filling, frequent overflow, and increased risks of environmental contamination.

Figure 3: Unlined pits are the simplest and quickest type of cesspit constructed in the Gaza Strip, especially in temporary displacement areas

Metal-barrel systems typically comprised two or more stacked 200-L barrels with removed bottoms and lateral openings to enhance seepage. Although these systems were inexpensive and rapidly installed, their limited storage capacity, structural deterioration, corrosion (in metal barrels), and uncontrolled leakage substantially reduced their effectiveness and increased risks of soil and groundwater contamination.

3.3.2. Masonry-Lined Cesspits

Masonry-lined cesspits were constructed using locally available concrete blocks, fired bricks, or natural stone to reinforce excavation walls and reduce structural collapse. Some pits were partially lined to permit limited infiltration, whereas others functioned primarily as temporary storage units. Poor workmanship, inadequate sealing, and damaged joints frequently compromised their integrity, increasing the potential for wastewater leakage into surrounding soils.

3.3.3. Metal- and Plastic Barrel-Based Cesspits

Metal- and plastic barrel-based systems were commonly used as low-cost emergency sanitation solutions where conventional construction materials were unavailable. These systems consisted of buried recycled barrels or plastic containers connected to household wastewater discharge pipes (Table 1). In many installations, the bases and sidewalls were perforated to facilitate infiltration into surrounding soils.

Figure 4: Various used plastic and metal barrels are sometimes utilized as structural components in the construction of household cesspits in the Gaza Strip

Table 1: Comparative Characteristics of Plastic and Iron Barrels Used in Household Cesspits in the Gaza Strip

Comparison Criteria	Plastic Drums (Polyethylene)	Iron Drums
Resistance and Durability	Excellent: Highly resistant to corrosion and generally unaffected by chemicals, acids, and moisture present in wastewater, resulting in a longer service life.	Poor: Highly susceptible to rusting and corrosion due to continuous exposure to moisture and saline conditions, which considerably reduces their operational lifespan.
Ease of Preparation and Installation	Very Easy: Can be easily cut and perforated using simple field tools, allowing rapid preparation and installation under emergency conditions.	Moderate to Difficult: Requires stronger tools (e.g., drills or chisels) for cutting and perforation. Cut edges may become sharp, creating safety hazards during installation and maintenance.
Resistance to Soil Pressure and Backfilling	Moderate: May deform or collapse inward under high external soil pressure if not properly supported with gravel, aggregate, or appropriate backfilling materials.	Good (Initially): Provides better resistance to external soil pressure during early operation; however, structural strength gradually declines as corrosion progresses.
Environmental and Operational Considerations	Provides a more durable option for temporary or semipermanent soak pits; however, leakage through perforations may result in uncontrolled wastewater infiltration into surrounding soils.	Offers a rapid and inexpensive emergency solution but has a shorter lifespan due to corrosion, increasing the risk of structural failure and wastewater leakage.

3.3.4. Reinforced Concrete Cesspits

Reinforced concrete cesspits represented the most structurally stable systems identified during field observations, although they were considerably less common because of higher material and construction requirements. Compared with unlined and partially lined pits, these systems provided greater storage capacity and reduced direct wastewater leakage. Nevertheless, their effective operation depended on routine emptying by vacuum tankers, a service that became severely disrupted because of fuel shortages, access restrictions, and the widespread collapse of sanitation services.

3.4. Septage Accumulation and Failure of Wastewater Emptying Services

Septage, the liquid and semi-solid waste accumulated in household cesspits, is normally removed through periodic vacuum tanker services. Field observations and documentary evidence indicated that the collapse of septage collection and wastewater emptying services became one of the principal causes of cesspit failure during the study period. Before October 2023, households relying on cesspits generally depended on regular emptying to maintain storage capacity. However, fuel shortages, destruction of municipal infrastructure and service vehicles, movement restrictions, and insecurity severely disrupted these operations. Consequently, many cesspits exceeded their storage capacity, resulting in wastewater overflow, leakage into surrounding environments, and uncontrolled discharge within residential areas and displacement camps.

The problem was particularly pronounced in overcrowded shelters, where wastewater generation increased while sanitation services remained largely unavailable. Furthermore, the inability to safely transport and dispose of collected septage increased the risk of secondary contamination of soils, groundwater, and public spaces. These findings indicate that the collapse of septage management transformed household cesspits from functioning onsite sanitation systems into major sources of environmental contamination, emphasizing the urgent need to restore emergency wastewater collection and safe disposal services.

3.5. Cesspit Overflow and Environmental Contamination

Frequent overflow of household cesspits was widely documented across densely populated residential areas and displacement camps following the deterioration of sanitation services (Figure 5). Overflowing cesspits discharged untreated domestic wastewater into streets, agricultural lands, public spaces, and around temporary shelters, resulting in widespread surface contamination and environmental degradation. Wastewater accumulation was repeatedly observed adjacent to residential buildings, displacement tents, and public facilities, creating continuous exposure pathways for humans, domestic animals, and surrounding ecosystems. The uncontrolled release of untreated wastewater introduced substantial quantities of organic matter, nutrients, suspended solids, pathogens, and household chemicals into terrestrial environments. Field observations further documented soil degradation, persistent foul odors, proliferation of flies and commensal rodents, and deterioration of living conditions in affected communities. In agricultural areas, wastewater leakage created additional concerns regarding crop contamination and pathogen transmission.

Collectively, these observations demonstrate that localized cesspit failures evolved into widespread environmental contamination following the collapse of wastewater management systems.

Figure 5: Overflowing cesspits in displacement camps have resulted in uncontrolled discharge of untreated wastewater, causing surface contamination, soil degradation, foul odors, insect and rodent proliferation, deterioration of living conditions, and increased risks of exposure to pathogenic microorganisms and waterborne diseases

3.6. Spatial Distribution and Vulnerability Hotspots of Household Cesspits

The environmental risks associated with household cesspits varied spatially across the Gaza Strip according to population density, groundwater vulnerability, infrastructure damage, and access to sanitation services. The highest-risk areas were identified in densely populated urban centers, displacement camps, and locations where sewerage networks had been severely damaged. Northern Gaza and Gaza City experienced substantial sanitation pressures owing to extensive infrastructure destruction and limited wastewater services, whereas Deir al-Balah, Khan Younis, Al-Mawasi, and Rafah emerged as major vulnerability hotspots because of the rapid concentration of displaced populations and widespread construction of emergency cesspits. Coastal and low-lying areas were particularly vulnerable because shallow groundwater conditions facilitate the movement of wastewater-derived contaminants toward the Gaza Coastal Aquifer and the Mediterranean Sea. These spatial differences highlight the uneven distribution of sanitation risks and identify priority areas for emergency wastewater management and environmental protection interventions.

3.7. Contamination Pathways from Household Cesspits

Field observations and documentary evidence identified multiple pathways through which contaminants originating from household cesspits may reach environmental and human receptors (**Figure 6**). The principal contamination sources included leakage from damaged or unlined cesspits, overflow of accumulated wastewater, and inappropriate disposal of septage and sludge. These contaminants were transported through infiltration into surrounding soils and groundwater, surface runoff into agricultural lands and open environments, and direct human contact with untreated wastewater. Insects and other mechanical vectors may further facilitate the indirect transmission of pathogens from sewage-contaminated environments to nearby human settlements. Potential receptors included displaced populations, agricultural workers, domestic animals, crops, groundwater resources, and coastal ecosystems.

The transport of microbial pathogens, nutrients, household chemicals, and other contaminants through these pathways contributes to environmental degradation and increases potential public health risks. The vulnerability of the Gaza Coastal Aquifer, combined with the region's high population density and dependence on groundwater resources, further amplifies the significance of these contamination pathways. Children, internally displaced persons, sanitation workers, farmers, and households relying on shallow groundwater wells were identified as the most vulnerable population groups because of their greater likelihood of exposure to contaminated wastewater and degraded sanitation conditions.

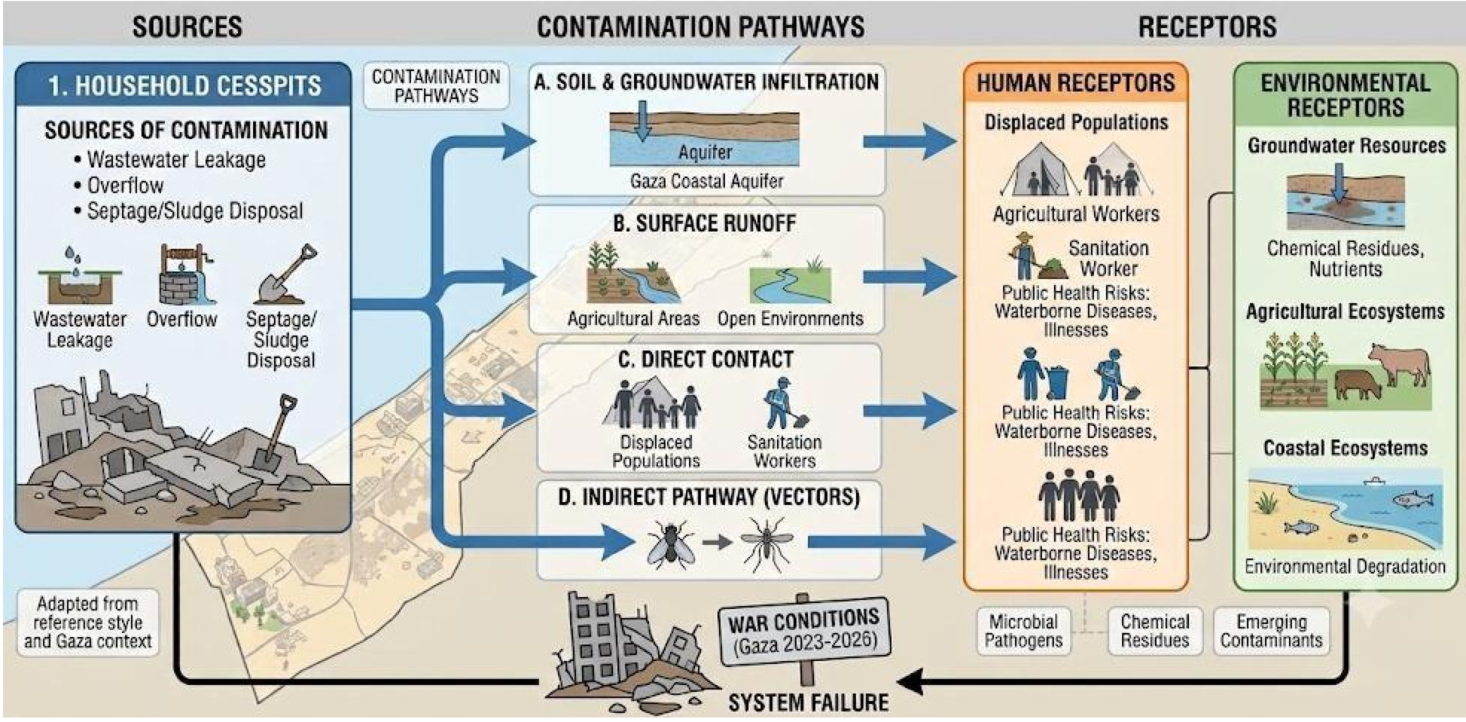

Figure 6: AI-generated conceptual framework illustrating contamination pathways from household cesspits to environmental and human receptors in the Gaza Strip

3.8. Public Health Impacts Associated with Household Cesspits

The widespread dependence on household cesspits, combined with the discharge of untreated wastewater and deterioration of sanitation services, created substantial public health risks throughout the Gaza Strip. Exposure occurred through direct contact with contaminated wastewater, polluted soils, and potentially contaminated water sources, increasing the likelihood of waterborne and sanitation-related diseases. The most vulnerable populations included children, internally displaced persons (IDPs), older adults, and residents of overcrowded shelters, where access to safe water, sanitation, hygiene facilities, and healthcare services remained severely limited. The principal health hazards associated with wastewater contamination include diarrheal diseases, gastrointestinal infections, intestinal parasitic infections, skin disorders, and other illnesses linked to fecal contamination.

In addition, stagnant wastewater surrounding overflowing cesspits created favorable conditions for the proliferation of disease-associated insects, increasing the potential for mechanical transmission of enteric pathogens and other sanitation-related health risks.

Intestinal Parasitic Infections

Untreated domestic wastewater may contain a wide range of intestinal protozoan and helminth parasites that can contaminate soils, water resources, and food production systems. Based on published local investigations and consultations with governmental and non-governmental health clinics operating in displacement camps, several medically important intestinal parasites were identified as potential sanitation-associated pathogens in the Gaza Strip (Table 2). These include *Giardia duodenalis*, *Entamoeba histolytica*, *Cryptosporidium parvum*, *Cyclospora cayetanensis*, *Blastocystis* sp., *Enterobius vermicularis*, *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Strongyloides stercoralis*, *Taenia saginata*, and *Hymenolepis nana*.

Table 2: Potential intestinal parasitic pathogens associated with wastewater contamination and sanitation deterioration in the Gaza Strip

Common name	Scientific name (authority)	Parasite group
Giardia	*Giardia duodenalis* (Kunstler, 1882)	Protozoan
Amoebic dysentery parasite	*Entamoeba histolytica* Schaudinn, 1903	Protozoan
Cryptosporidium parasite	*Cryptosporidium parvum* Tyzzer, 1912	Protozoan
Cyclospora parasite	*Cyclospora cayetanensis* Ortega, Gilman & Sterling, 1994	Protozoan
Blastocystis parasite	*Blastocystis* sp.	Protozoan
Pinworm (Threadworm)	*Enterobius vermicularis* (Linnaeus, 1758)	Helminth (Nematode)
Roundworm	*Ascaris lumbricoides* Linnaeus, 1758	Helminth (Nematode)
Whipworm	*Trichuris trichiura* (Linnaeus, 1771)	Helminth (Nematode)
Hookworm	*Ancylostoma duodenale* (Dubini, 1843)	Helminth (Nematode)
Strongyloidiasis parasite	*Strongyloides stercoralis* (Bavay, 1876)	Helminth (Nematode)
Taeniasis parasite (Beef tapeworm)	*Taenia saginata* Goeze, 1782	Helminth (Cestode)
Dwarf tapeworm	*Hymenolepis nana* (von Siebold, 1852)	Helminth (Cestode)

**This table was developed by the authors based on published local studies and consultations with governmental and non-governmental health clinics operating in displacement camps and across the Gaza Strip during the ongoing war.*

Skin Diseases among Displaced Populations

Field observations and documentary evidence indicated that overflowing cesspits substantially increased exposure of displaced children to untreated wastewater, contributing to widespread skin diseases in overcrowded displacement camps (Figure 7). Wastewater ponds, open sewage channels, and contaminated ground surfaces frequently occurred between tents and collective shelters, where children were routinely exposed during daily activities. The health risks were further aggravated by limited access to clean water, inadequate personal hygiene supplies, overcrowding, malnutrition, high ambient temperatures, and the proliferation of diseaseassociated insects. Healthcare providers and field clinics reported large numbers of patients presenting with skin infections under these conditions. Commonly reported conditions included scabies, impetigo, fungal dermatoses, intertrigo, and other bacterial, fungal, and parasitic skin diseases, reflecting the combined effects of prolonged wastewater exposure and deteriorating living conditions.

Figure 7: Skin diseases among displaced children associated with overflowing household cesspits in the Gaza Strip

Insect Proliferation

Overflowing cesspits, stagnant wastewater, accumulated organic waste, and poor drainage created suitable breeding and feeding habitats for several sanitation-associated insect species in displacement camps (**Figure 8**). The most frequently encountered insects included the house fly (*Musca domestica* Linnaeus, 1758), oriental latrine fly (*Chrysomya megacephala* Fabricius, 1794), common house mosquito (*Culex pipiens* Linnaeus, 1758), and American cockroach (*Periplaneta americana* Linnaeus, 1758) (**Table 3**). These species are closely associated with sewagecontaminated environments and may contribute to food contamination, mechanical transmission of enteric pathogens, and increased nuisance biting.

Table 3: Major insects associated with cesspit overflow and sewage contamination in displacement camps across the Gaza Strip

Common name	Scientific name	Family	Order	Association with cesspit overflow and sewage-contaminated environments	Potential public health significance
House Fly	*Musca domestica* Linnaeus, 1758	Muscidae	Diptera	Breeds in fecal matter, sewage sludge, and accumulated organic waste around overflowing cesspits	Mechanical transmission of enteric pathogens and food contamination
Blow Fly (Oriental Latrine Fly)	*Chrysomya megacephala* Fabricius, 1794	Calliphoridae	Diptera	Accumulation of uncollected solid waste, human excreta, decomposing food, animal carcasses, open sewage, and high ambient temperatures	Mechanical transmission of bacteria and contamination of food and wounds
Common House Mosquito	*Culex pipiens* Linnaeus, 1758	Culicidae	Diptera	Breeds in stagnant wastewater, cesspit leakage, and water pools formed around shelters	Potential vector of mosquitoborne pathogens and severe biting nuisance
American Cockroach	*Periplaneta americana* Linnaeus, 1758	Blattidae	Blattodea	Common around sewage channels, wastewater areas, drains, and contaminated buildings	Spread of bacteria and contamination of food and surfaces

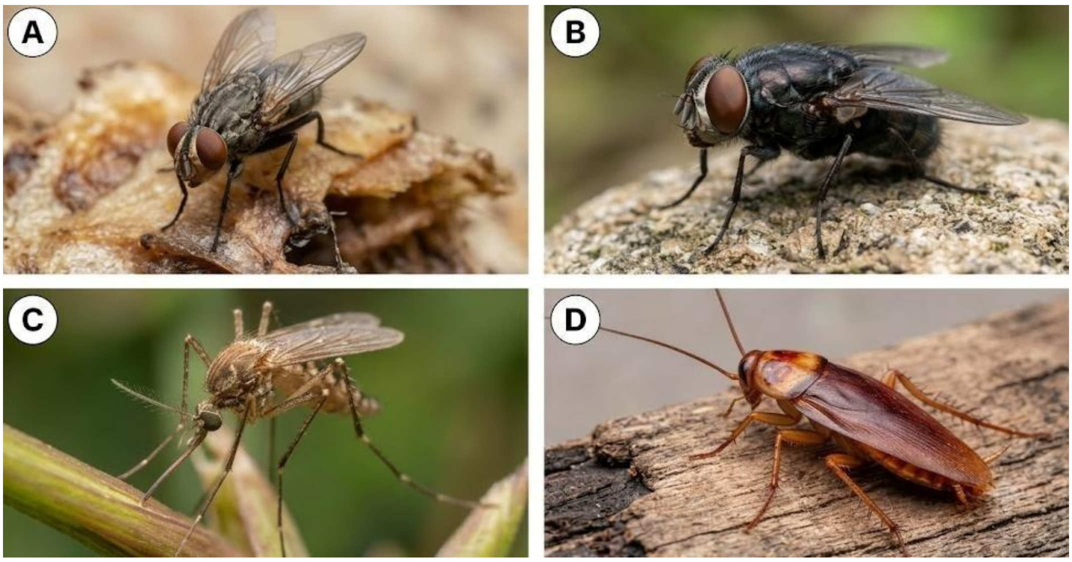

Figure 8: Examples of insects that prevail in the displacement camps environments across the Gaza Strip: (A) House Fly (Musca domestica Linnaeus, 1758); (B) Blow or Oriental Latrine Fly (Chrysomya megacephala Fabricius, 1794); (C) Common House Mosquito (Culex pipiens Linnaeus, 1758); and (D) American Cockroach (Periplaneta americana Linnaeus, 1758)

Rodent Proliferation

Although overflowing cesspits do not serve as breeding sites for rodents, they create favorable ecological conditions by increasing food availability, shelter, and movement corridors. Combined with accumulated solid waste and damaged urban infrastructure, these conditions promoted the proliferation of commensal rodents in displacement camps. The principal species identified were the house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), and black rat (*Rattus rattus*) (Table 4; Figure 9). Their increased abundance poses additional concerns through contamination of food supplies, living environments, and potential transmission of rodentassociated pathogens.

Table 4: Commensal Rodents Associated with Overflowing Cesspits and Damaged Sewerage in Gaza Strip Displacement Camps

Order	Family	Scientific Name	Common Name
Rodentia	Muridae	*Mus musculus* Linnaeus, 1758	House Mouse
Rodentia	Muridae	*Rattus norvegicus* Berkenhout, 1769	Norway Rat
Rodentia	Muridae	*Rattus rattus* Linnaeus, 1758	Black Rat

Figure 9: The House Mouse (Mus musculus Linnaeus, 1758), a commensal rodent associated with overflowing cesspits and deteriorated sewerage infrastructure in displacement camps across the Gaza Strip

Occupational Hazards Associated with Emergency Cesspit Construction

Emergency excavation of household cesspits also created significant occupational hazards. Field observations indicated that cesspits were commonly excavated manually without engineering supervision, excavation wall support, or appropriate personal protective equipment. At least one fatal incident was documented in Al-Mawasi, Khan Younis, where the collapse of an unsupported excavation approximately 2.5 m deep resulted in the death of a worker by suffocation after burial beneath unstable soil. This incident illustrates the severe occupational risks associated with emergency sanitation construction under crisis conditions and highlights the need for basic excavation safety measures and worker protection.

3.9. Environmental and Ecological Impacts of Household Cesspits

3.9.1. Groundwater Contamination Risks

Field observations and documentary evidence indicate that household cesspits constitute a major potential source of groundwater contamination in the Gaza Strip. The widespread use of damaged, overloaded, and poorly constructed cesspits, together with the region's shallow coastal aquifer and high dependence on groundwater for domestic and agricultural purposes, increases the likelihood of contaminant migration into groundwater resources.

Leakage from cesspits may introduce fecal indicator bacteria, pathogenic microorganisms, nutrients, organic pollutants, and household chemical residues into the aquifer, posing significant environmental and public health concerns. The deterioration of sanitation infrastructure further intensified these risks by increasing wastewater retention times, reducing safe disposal options, and expanding the number of overloaded cesspits. The proximity of many household cesspits to domestic wells further increases groundwater vulnerability. Reflecting these concerns, the Water and Environment Quality Authority in the Gaza Strip recently issued a public awareness poster highlighting the risks of cesspit-derived groundwater contamination (Figure 10).

Figure 10: Arabic-language awareness poster issued by the Water and Environment Quality Authority in the Gaza Strip highlighting the environmental risks of household cesspits, particularly groundwater contamination

3.9.2. Agricultural Land and Food Safety

Wastewater leakage and overflow from household cesspits were frequently observed adjacent to agricultural lands, creating potential risks to soil quality, food safety, and agricultural sustainability. Untreated wastewater may introduce fecal microorganisms, intestinal parasites, nutrients, and household chemical contaminants into agricultural soils, increasing the likelihood of crop contamination and pathogen transmission, particularly through raw vegetables. Persistent parasite eggs and microbial pathogens in wastewater-contaminated soils may also increase occupational exposure among farmers and nearby communities. The destruction of sanitation infrastructure, limited availability of safe irrigation water, and prolonged water shortages have further increased these risks. Although direct contamination of crops was not assessed in this study, the widespread occurrence of wastewater overflow indicates considerable potential threats to food security, agricultural productivity, and public health in the Gaza Strip.

3.9.3. Ecological Impacts

The extensive leakage and overflow of household cesspits adversely affected terrestrial and aquatic ecosystems throughout the Gaza Strip. Wastewater infiltration altered soil characteristics, increased nutrient loading, and contributed to localized environmental degradation. Transport of contaminants through surface runoff and groundwater pathways may also facilitate the movement of pollutants toward coastal environments, placing additional pressure on Mediterranean marine ecosystems.

Potential ecological consequences include eutrophication, deterioration of coastal water quality, and exposure of marine organisms to pathogenic microorganisms and wastewater-derived contaminants. These impacts occurred alongside other war-related environmental pressures, including debris accumulation, disrupted solid waste management, and habitat disturbance, collectively contributing to widespread ecosystem degradation and increasing the complexity of environmental recovery.

3.10. Photographic and Documentary Evidence

Photographic documentation obtained during field investigations, together with images collected from reliable news outlets, humanitarian organizations, and verified social media sources, consistently demonstrated widespread sanitation deterioration across the Gaza Strip. The photographs documented overflowing cesspits, wastewater accumulation around residential buildings and displacement shelters, stagnant sewage pools, damaged sanitation infrastructure, and improvised wastewater disposal practices.

Collectively, the visual evidence confirms the transition from pre-existing sanitation limitations to a severe environmental and public health emergency following the collapse of wastewater management systems. These records also corroborate field observations of increased dependence on household cesspits and the widespread discharge of untreated wastewater throughout affected communities.

3.11. Summary of Major Risks

The findings demonstrate that household cesspits have become a central component of the sanitation crisis in the Gaza Strip following the widespread destruction of wastewater infrastructure and the collapse of centralized sanitation services. Increased reliance on household cesspits, together with disrupted maintenance, fuel shortages, population displacement, and overcrowding, has intensified wastewater accumulation, overflow, and uncontrolled environmental discharge. These changes have expanded contamination pathways affecting soils, groundwater resources, residential environments, agricultural lands, and coastal ecosystems while substantially increasing environmental and public health risks (Table 5).

Table 5: Major environmental, public health, ecological, and humanitarian risks associated with household cesspits in the Gaza Strip during Israel's ongoing war of genocide and ethnic cleansing (2023–2026)

Risk category	Main sources/processes	Environmental and health consequences
Wastewater overflow and surface contamination	Overloaded cesspits, reduced wastewater removal capacity, destruction of sewerage networks, fuel shortages, and increased wastewater generation in displacement camps	Accumulation of untreated wastewater in streets, residential areas, agricultural lands, and displacement sites; foul odors; soil contamination; deterioration of living conditions
Groundwater contamination	Leakage from unlined, damaged, or overloaded cesspits; prolonged wastewater retention; shallow coastal aquifer; proximity of cesspits to wells	Increased risk of groundwater contamination by fecal bacteria, pathogens, nutrients, organic pollutants, and household chemical residues; reduced suitability of groundwater for domestic and agricultural use
Microbial contamination and sanitation-related diseases	Direct exposure to untreated wastewater, contaminated soils, and polluted water sources containing fecal microorganisms	Increased risks of diarrheal diseases, gastrointestinal infections, intestinal parasitic infections, and other fecal–oral transmission diseases
Skin diseases among displaced populations	Direct contact with sewage-contaminated environments, overflowing cesspits, wastewater channels between tents, poor hygiene conditions, overcrowding, and limited access to clean water	Increased prevalence of scabies, impetigo, fungal infections, intertrigo, and other bacterial, fungal, and parasitic skin disorders, particularly among children
Chemical contamination	Infiltration of household chemicals, detergents, pharmaceuticals, and wastewater-associated pollutants from cesspits into soils and groundwater	Potential accumulation of toxic substances affecting human health, soil quality, and ecosystem integrity
Vector proliferation	Stagnant wastewater pools, sewage-contaminated areas, organic waste accumulation, and poor drainage conditions	Increased abundance of flies, mosquitoes, cockroaches, and other disease-associated arthropods; enhanced potential for pathogen transmission and nuisance biting
Rodent proliferation and pest problems	Availability of food sources, shelter, movement pathways, accumulated solid waste, damaged infrastructure, and deteriorated sanitation conditions	Increased presence of commensal rodents around displacement camps; potential contamination of food and living spaces and increased public health concerns
Agricultural and food safety impacts	Wastewater leakage into agricultural areas and potential use of contaminated water for irrigation	Soil degradation, possible crop contamination, reduced agricultural quality, and increased risks of foodborne pathogen transmission
Marine and coastal ecosystem contamination	Transport of wastewater pollutants through surface runoff and groundwater discharge into the Mediterranean Sea	Increased nutrient loading, microbial contamination, eutrophication risks, deterioration of coastal water quality, and additional stress on marine biodiversity
Occupational hazards during cesspit construction	Emergency manual excavation without engineering supervision, wall reinforcement, or personal protective equipment	Risk of excavation collapse, suffocation, injuries, and fatalities among workers involved in emergency sanitation construction
Humanitarian sanitation crisis	Destruction of wastewater infrastructure, mass displacement, overcrowded shelters, limited sanitation alternatives, and reduced municipal services	Prolonged exposure to unsafe environments, deterioration of public health conditions, increased disease vulnerability, and worsening humanitarian conditions

Overall, household cesspits have shifted from a long-standing sanitation limitation to a major environmental and public health emergency. The interaction between damaged infrastructure, increased wastewater generation, limited wastewater management capacity, and widespread population displacement has intensified contamination pathways and increased risks to human populations, groundwater resources, agricultural systems, and ecosystems throughout the Gaza Strip.

4. DISCUSSION

The findings demonstrate that household cesspits in the Gaza Strip have shifted from a longstanding decentralized sanitation practice into a major environmental and public health emergency. Before October 2023, approximately 14.6% of housing units depended on cesspits or holding pits [23], reflecting incomplete sewerage coverage and longstanding infrastructural, technical, and financial constraints [9] [21] [22] [42]. During Israel's ongoing war of genocide and ethnic cleansing (2023–2026), the destruction of wastewater treatment plants, sewerage networks, pumping stations, electricity supplies, service vehicles, and access routes, coupled with mass displacement, generated an unprecedented demand for emergency sanitation. Consequently, the reported construction of approximately 320,000 informal cesspits represents both a major expansion of onsite sanitation and a severe decline in its safety and environmental performance [41].

This transformation reflects the vulnerability of water and sanitation systems during the brutal war, when infrastructure destruction, fuel shortages, restricted maintenance, and loss of technical capacity can convert pre-existing deficiencies into prolonged public health emergencies [2] [3]. Satellite-detected damage to the Gaza Strip's WASH infrastructure supports field observations of sewerage failure and reduced wastewater-management capacity [38]. Moreover, longstanding political and resource constraints had already weakened the Gaza Strip's water and sanitation sector and limited its capacity to withstand such extensive destruction [43]. The cesspit crisis should therefore be understood as a systemic consequence of infrastructure collapse, displacement, overcrowding, fuel scarcity, and disruption of municipal services rather than the isolated failure of individual household systems.

The four documented cesspit types varied substantially in structural stability and contaminantrelease potential. Reinforced-concrete systems provided better containment but still depended on regular emptying, whereas unlined pits and perforated barrels allowed untreated wastewater to infiltrate surrounding soils. Cracks, incomplete sealing, and poor workmanship also compromised masonry-lined pits. Cesspits have historically functioned as localized systems for the collection and disposal of human waste, with their environmental performance depending strongly on containment, maintenance, and site conditions [4]. Palestinian investigations have shown that partially sealed cesspits receive variable wastewater loads and contain septage with considerable organic and nutrient pollution [25]-[27]. Household cesspit wastewater also exhibits substantial chemical and microbial heterogeneity [44]. Thus, the risks vary according to cesspit design, materials, capacity, hydraulic behavior, location, and maintenance.

The collapse of septage collection was a principal cause of cesspit overflow. Onsite systems require an integrated chain of emptying, transportation, treatment, and safe final disposal because failure at any stage can transfer pollution from a contained pit to streets, open land, or agricultural areas [27] [45]. During the Israeli war, fuel shortages, damaged vacuum tankers, movement restrictions, insecurity, and loss of disposal facilities disrupted this chain, transforming both infiltrating pits and sealed storage systems into environmental hazards. Although overflow-prevention technologies may offer localized benefits under normal conditions [46], they cannot replace functional collection, treatment, and disposal services.

The Gaza Strip coastal aquifer is the receptor of greatest long-term concern because it is shallow, highly vulnerable, and already degraded by over-abstraction, seawater intrusion, agricultural inputs, and wastewater infiltration [13] [15] [16]. Leakage from densely clustered cesspits may introduce fecal microorganisms, nitrate, nutrients, organic matter, detergents, pharmaceuticals, and other contaminants into groundwater. The source–pathway–receptor model is particularly applicable because poorly contained wastewater sources occur above permeable soils and an aquifer used by exposed populations [10]. Studies elsewhere have confirmed pathogen migration from onsite sanitation facilities to groundwater where separation distances are inadequate and hydrogeological conditions permit rapid transport [47].

However, this study did not directly measure cesspit-derived groundwater contamination. Its findings indicate a substantial and scientifically plausible risk rather than proving contamination of particular wells. Gaza Strip's groundwater is affected by multiple sources, including fertilizers, damaged sewerage networks, treatment facilities, seawater intrusion, and historical pollution [20] [29]. Future investigations should therefore combine fecal indicators, microbial source tracking, nitrate and nitrogen-isotope analysis, chemical tracers, groundwater monitoring, and spatial mapping of cesspit–well distances to distinguish cesspit contributions and identify priority protection zones.

Overflowing cesspits also threaten agricultural soils and food safety by introducing enteric pathogens, parasite stages, nutrients, salts, detergents, pharmaceuticals, and other contaminants [10] [27] [48]. Although nutrient inputs may temporarily promote plant growth, uncontrolled loading can degrade soils and create microbial and chemical hazards. Previous studies in the Gaza Strip examined farmers' perceptions of sewage-sludge use and emphasized the importance of appropriate treatment and pollution-control measures before the agricultural reuse of wastewater or sludge [49] [50]. Parasitic infections have also been investigated among Palestinian farmers exposed to treated wastewater [51], while persistent pharmaceutical and chemical residues introduce additional uncertainty into soil–crop systems [52]. Although crops were not directly tested, wastewater overflow near agricultural land and vegetables potentially consumed raw warrants precautionary restrictions and food-safety surveillance.

Pollutants may also move through runoff, drainage, and groundwater discharge toward Wadi Gaza and the Mediterranean coast. Previous studies documented the ecological importance of Wadi Gaza and the environmental pressures associated with wastewater inputs [53] [54], while the Beit Lahia wastewater-treatment system demonstrated the effects of poorly managed wastewater on land, groundwater, wildlife habitats, and surrounding communities [35]. During the Israeli war, cesspit leakage interacts with damaged sewerage, solid waste, debris, habitat destruction, and direct wastewater discharge, producing cumulative ecological pressures that may increase microbial pollution, nutrient enrichment, eutrophication, and stress on coastal biodiversity [33] [39] [55]. The specific contribution of cesspits nevertheless requires hydrological tracing and coordinated terrestrial, groundwater, and marine monitoring.

Public health risks arise through contact with overflowing wastewater, contaminated soil, unsafe water and food, and sewage-contaminated objects.

Intestinal parasites have previously been documented among different population groups in the Gaza Strip [56]-[58], and parasitic contamination has been detected in Gaza Strip's coastal seawater [32]. These findings confirm the local presence of relevant pathogens but do not establish cesspits as the source of infections recorded during the war. Evidence from the war-affected Tigray Region in northern Ethiopia showed a strong association between inadequate water and sanitation conditions and childhood diarrhea [37]. Similarly, the extensive destruction of WASH infrastructure in the Gaza Strip has created conditions conducive to the transmission of enteric diseases [38].

The listed intestinal parasites should therefore be regarded as potential sanitation-associated hazards rather than confirmed cesspit-derived infections. Some protozoa spread rapidly through contaminated water and food, whereas several helminths require development in soil, suitable environmental conditions, or intermediate hosts. Historical cesspool studies demonstrate the long-term persistence of certain helminth eggs in fecally contaminated environments [59]-[61]. Likewise, skin disorders among displaced children may reflect sewage exposure together with overcrowding, heat, malnutrition, inadequate washing water, limited soap, shared bedding, scabies transmission, and delayed treatment. Stool examinations, wastewater analyses, molecular identification, and epidemiological comparisons are therefore necessary before attributing specific parasitic or skin diseases directly to cesspit exposure.

Sewage, organic waste, and stagnant water also support flies, mosquitoes, cockroaches, and commensal rodents. Stagnant and polluted water can provide suitable breeding habitats for mosquitoes, including *Culex* species, while increasing biting nuisance and potentially facilitating mosquito-borne pathogen transmission [62] [63]. House Flies, Oriental Latrine Flies, and cockroaches may mechanically transfer microorganisms to food and surfaces, while cesspit environments can sustain distinctive insect assemblages [64]. Vector presence alone, however, does not confirm pathogen carriage or active transmission. Rodents are indirectly favored by accumulated refuse, rubble, damaged sewers, food waste, and poorly protected shelters [65] [66]. Gastrointestinal parasites and ectoparasites have been documented in Black Rats (*Rattus rattus* Linnaeus, 1758) from the Gaza Strip [67], and recent vertebrate-pest outbreaks in displacement camps have been linked to environmental disruption and waste accumulation [66] [68]. Integrated control should therefore combine sanitation restoration, solid-waste removal, food protection, shelter improvement, and entomological and rodent surveillance.

Emergency cesspit construction additionally creates serious occupational hazards. Manual excavation in unstable soils without shoring, safe access, engineering supervision, or appropriate personal protective equipment exposes workers to excavation collapse, burial, suffocation, falls, sewage, sharp objects, and potentially hazardous atmospheres [69] [70]. The documented fatal collapse of an unsupported cesspit excavation in Al-Mawasi illustrates these risks [41]. Excavation-safety guidance emphasizes the use of soil-appropriate protective systems, including sloping, shoring, or shielding, together with barriers, safe access and egress, atmospheric assessment where necessary, and appropriate worker protection [69]. Occupational safety must therefore be incorporated into emergency sanitation programs.

Constructing additional pits is not a sustainable response where land is limited, groundwater is shallow, camps are overcrowded, and emptying services are unreliable. Palestinian research has demonstrated the potential of source separation, greywater treatment, decentralized wastewater treatment, and controlled reuse where appropriate safeguards are applied [71]-[76]. Emergency options may include sealed holding tanks, raised facilities in shallow-groundwater areas, shared sanitation linked to scheduled emptying, designated septage-transfer points, and rapid treatment units. Their selection should reflect population density, soil permeability, groundwater depth, accessibility, displacement duration, water availability, and maintenance capacity.

A phased response is needed. Immediate priorities include securing overflowing or unstable pits, restoring desludging equipment and fuel, providing sealed containment, restricting access to contaminated areas, and supplying water, soap, protective equipment, and pest-control services. Priority mapping should target densely populated and low-lying areas, particularly where cesspits are close to wells or agricultural land. Medium-term action should restore sewerage networks, pumping stations, treatment plants, service vehicles, and regulated septage disposal. Long-term recovery should integrate groundwater-vulnerability mapping, climate resilience, decentralized treatment where appropriate, wastewater-reuse standards, and routine inspection, while addressing the institutional and political constraints affecting sanitation sustainability [43] [75].

This study integrated field observations, photographs, scientific literature, and documentary sources under conditions that severely restricted systematic monitoring. Nevertheless, its findings remain descriptive because insecurity prevented representative site selection, comprehensive mapping, seasonal sampling, environmental analysis, pathogen detection, disease-incidence assessment, and quantitative risk modeling. The reported estimate of approximately 320,000 emergency cesspits should be independently verified using municipal and humanitarian records, remote sensing, and field surveys. Photographic and social-media evidence may also involve spatial and reporting biases.

Future research should establish a georeferenced cesspit inventory incorporating construction type, served population, soil characteristics, groundwater depth, distance from wells, filling rate, and emptying history. Environmental monitoring should examine fecal indicators, pathogens, nutrients, salinity, pharmaceuticals, detergents, heavy metals, and antimicrobial-resistant organisms, while health surveillance should address diarrheal disease, parasitic infections, skin disorders, pest abundance, and occupational injuries. Compliance assessment against recognized onsite-sanitation standards could support reconstruction and inspection [77]. A One Health framework linking human and animal health with groundwater, soil, pests, agriculture, and coastal ecosystems is particularly appropriate.

Overall, emergency cesspits are both indicators and amplifiers of the Gaza Strip's wider WASH collapse. Their cumulative interaction with shallow groundwater, damaged infrastructure, overcrowded communities, agricultural land, and coastal ecosystems creates substantial environmental and health risks. Restoring safely managed sanitation is therefore essential for immediate humanitarian protection and the long-term recovery of the Gaza Strip's water resources, food systems, ecosystems, and population health.

5. CONCLUSION

Household cesspits have shifted from a chronic sanitation limitation into a major environmental, public health, and humanitarian emergency during Israel's ongoing war of genocide and ethnic cleansing (2023–2026). Infrastructure destruction and mass displacement have driven widespread reliance on improvised, unlined, overloaded, and poorly maintained pits, creating credible pathways for wastewater contaminants to reach residential areas, soils, agricultural land, groundwater, and coastal ecosystems. These conditions increase the potential for enteric and parasitic infections, skin disorders, food contamination, pest proliferation, and occupational injury, although direct causation could not be established without laboratory and epidemiological measurements. Priorities include safe wastewater containment, restored septage services, protection of wells and farmland, excavation safety, hygiene support, and pest management. Long-term recovery requires resilient wastewater infrastructure, reduced dependence on unregulated cesspits, groundwater-vulnerability mapping, and coordinated environmental and public health surveillance.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge all individuals, residents, sanitation workers, healthcare personnel, municipal staff, and humanitarian organizations who contributed field observations, photographic documentation, technical information, and firsthand accounts concerning household cesspits and sanitation conditions in the Gaza Strip. Their assistance was particularly valuable under the severe insecurity, displacement, movement restrictions, and infrastructure destruction associated with Israel's ongoing war of genocide and ethnic cleansing (2023–2026). The author also expresses sincere appreciation to everyone who supported the documentation of the environmental and public health consequences of the sanitation crisis under these exceptionally difficult circumstances.

REFERENCES

1. WHO – World Health Organization (2018). Guidelines on sanitation and health. World Health Organization. https://iris.who.int/handle/10665/274939
2. Schillinger, J., Özerol, G., Güven-Griemert, Ş., & Heldeweg, M. (2020). Water in war: Understanding the impacts of armed conflict on water resources and their management. *WIREs Water*, 7(6), e1480. https://doi.org/10.1002/wat2.1480
3. Shumilova, O., Tockner, K., Sukhodolov, A., Khilchevskyi, V., De Meester, L., Stepanenko, S., Trokhymenko, G., Hernández-Agüero, J. A., & Gleick, P. (2023). Impact of the Russia– Ukraine armed conflict on water resources and water infrastructure. *Nature Sustainability*, 6(5), 578–586. https://doi.org/10.1038/s41893-023-01068-x
4. Hall, A. R., & Kenward, H. K. (2016). Sewers, cesspits and middens: A survey of the evidence for 2000 years of waste disposal in York, UK. *Sanitation, Latrines and Intestinal Parasites in Past Populations*, 99–120.
5. Jansen, G. (2018). Sewers or cesspits? Modern assumptions and Roman preferences. In S. Hoss (Ed.), *Latrinae: Roman Toilets in the Northwestern Provinces of the Roman Empire* (pp. 5–18). Archaeopress.
6. Butler, D., & Payne, J. (1995). Septic tanks: Problems and practice. *Building and Environment*, 30(3), 419–425.
7. United States Environmental Protection Agency (USEPA). (2002). Onsite wastewater treatment systems manual (EPA/625/R-00/008). Office of Water and Office of Research and Development, U.S. Environmental Protection Agency. https://www.epa.gov/sites/default/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf
8. Metcalf & Eddy, Inc., & AECOM. (2014). *Wastewater engineering: Treatment and resource recovery* (5th ed.). McGraw-Hill Education. ISBN: 978-0-07-340118-8.
9. Thaher, R. A., Mahmoud, N., Al-Khatib, I. A., & Hung, Y. (2022). Cesspits as onsite sanitation facilities in the non-sewered Palestinian rural areas: Users' satisfaction, needs and perception. *Water*, 14(6), 849. https://doi.org/10.3390/w14060849
10. Mbae, M., Hansen, P., Way, C., Fenner, R., Graham, J. P., Pedley, S., Ensink, J. H. J., & Wright, J. (2024). Onsite sanitation systems and contamination of groundwater: A systematic review of the evidence for risk using the source–pathway–receptor model. *PLOS Water*, 3(7), e0000167. https://doi.org/10.1371/journal.pwat.0000167
11. WHO – World Health Organization (2022). *Sanitation safety planning: Manual for safe use and disposal of wastewater, greywater and excreta* (2nd ed.). World Health Organization. https://www.who.int/publications/i/item/9789240062887
12. Al-Agha, M. R. (1997). Environmental management in the Gaza Strip. *Environmental Impact Assessment Review*, 17(1), 65–76.
13. Weinthal, E., Vengosh, A., Marei, A., Gutierrez, A., & Kloppmann, W. (2005). The water crisis in the Gaza Strip: Prospects for resolution. *Groundwater*, 43(5), 653–660.
14. Baalousha, H. (2006). Desalination status in the Gaza Strip and its environmental impact. *Desalination*, 196(1-3), 1–12.
15. Baalousha, H. (2008). Analysis of nitrate occurrence and distribution in groundwater in the Gaza Strip using major ion chemistry. *Global NEST Journal*, 10(3), 337–349.
16. Shomar, B., El-Madhoun, F., & Yahya, A. (2010). Wastewater reuse for alfalfa production in the Gaza Strip. *Water, Air, & Soil Pollution*, 213(1), 105–119.
17. Al-Juaidi, A. E., Rosenberg, D. E., & Kaluarachchi, J. J. (2011). Water management with wastewater treatment and reuse, desalination, and conveyance to counteract future water shortages in the Gaza Strip. *International Journal of Water Resources and Environmental Engineering*, 3(12), 266–282.
18. Aiash, M., & Mogheir, Y. (2017). Comprehensive solutions for the water crisis in Gaza Strip. *IUG Journal of Natural Studies*, 25(3), 63–74.
19. Shomar, B., Yahya, A., & Müller, G. (2010). Elevated nitrate levels in the groundwater of the Gaza Strip: Distribution and sources. *Environmental Geology*, 60(7), 1431–1441.
20. Abbas, M., Barbieri, M., Battistel, M., Brattini, G., Garone, A., & Parisse, B. (2013). Water quality in the Gaza Strip: The present scenario. *Journal of Water Resource and Protection*, 5(1), 54–63.
21. MacDonald, E., Herrador, B., Hyllestad, S., Lund, V., Nygard, K., & Vold, L. (2016). Water usage in the Gaza Strip: Recommendations from a literature review and consultations with experts. *Eastern Mediterranean Health Journal*, 22(12), 910–918. https://doi.org/10.26719/2016.22.12.910
22. Ives, M. C., Hickford, A. J., Adshead, D., Thacker, S., Hall, J. W., Nicholls, R. J., et al. (2019). A systems-based assessment of Palestine's current and future infrastructure requirements. *Journal of Environmental Management*, 234, 200–213. https://doi.org/10.1016/j.jenvman.2018.12.058
23. PCBS – Palestinian Central Bureau of Statistics (2018). *Population, Housing and Establishment Census 2017 – Final Results, Housing Report, Gaza Strip*. Ramallah, Palestine.

24. Borst, B., Mahmoud, N. J., van der Steen, N. P., & Lens, P. N. (2013). A case study of urban water balancing in the partly sewered city of Nablus-East (Palestine) to study wastewater pollution loads and groundwater pollution. *Urban Water Journal*, 10(6), 434–446.
25. Al-Atawneh, N., Mahmoud, N., van der Steen, P., & Lens, P. N. (2014). Wastewater characteristics in partially sealed cesspit: A case study from Beit Dajan, Palestine. *Linnaeus Eco-Tech*, 14–23.
26. Al-Atawneh, N., Mahmoud, N., van der Steen, P., & Lens, P. N. (2016). Characterizations of Septage in partially sealed cesspit. *Journal of Water, Sanitation and Hygiene for Development*, 6(4), 631–639.
27. Amous, B., Mahmoud, N., van der Steen, P., & Lens, P. N. (2020). Septage composition and pollution fluxes from cesspits in Palestine. *Journal of Water, Sanitation and Hygiene for Development*, 10(4), 905–915.
28. Shomar, B., & Rovira, J. (2023). Human health risks associated with the consumption of groundwater in the Gaza Strip. *Heliyon*, 9(11), e21989. https://doi.org/10.1016/j.heliyon.2023.e21989
29. Abu Amr, S. S., Yassin, M. M., Al-Slaiman, K. A., & Al-Razi, A. M. (2023). Human health risks associated with the consumption of groundwater in the Gaza Strip. *Heliyon*, 9(11), e21989.
30. Lubbad, S., & Alfarra, A. (2004). Health effect due to poor waste water in Gaza Strip. *Social Science Research Network (SSRN)*. https://doi.org/10.2139/ssrn.1457842
31. Abu-Alrub, S. M., Abusada, G. M., Farraj, M. A., & Essawi, T. A. (2008). Prevalence of *Cryptosporidium* spp. in children with diarrhea in the West Bank, Palestine. *The Journal of Infection in Developing Countries*, 2(1), 59–062.
32. Hilles, A. H., Al Hindi, A. I., & Abu Safieh, Y. A. (2014). Assessment of parasitic pollution in the coastal seawater of Gaza City. *Journal of Environmental Health Science and Engineering*, 12(1), 26.
33. United Nations Environment Program – UNEP (2024). *Environmental impact of the conflict in Gaza: Preliminary assessment of environmental impacts*. United Nations Environment Program. https://wedocs.unep.org/20.500.11822/45739
34. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Fayyad, N. A., Al-Zain, B. F., Ali, A. S., & Hamad, D. M. (2007). On the benefits provided by the wetland ecosystem of Wadi Gaza – Gaza Strip. *Theme XII: Environmental Design Trends and Pollution Control, The 2nd International Engineering Conference on Construction and Development (IECCD-II)*, Islamic University of Gaza, Gaza Strip, Palestine, September 3-4, 2007, 44-58.
35. Abd Rabou, A. N. (2011). Environmental impacts associated with the Beit Lahia wastewater treatment plant, North Gaza Strip, Palestine. *Middle-East Journal of Scientific Research*, 7(5), 746–757.
36. Abd Rabou, A. N. (2013). Priorities of scientific research in the fields of marine environment and fishery resources in the Gaza Strip – Palestine. *Priorities of Scientific Research in Palestine: Towards a National Directory of Scientific Research*, March 25-26, 2013, Scientific Research Affairs, Islamic University of Gaza, Gaza Strip, Palestine, 481522.
37. Asgedom, A. A., Abirha, B. T., Tesfay, A. G., et al. (2023). Unimproved water and sanitation contributes to childhood diarrhea during the war in Tigray, Ethiopia. *Scientific Reports*, 13, 7800. https://doi.org/10.1038/s41598-023-35026-6
38. Perlman, B., Collins, S. M., & Van Den Hoek, J. (2025). Public health implications of satellite-detected widespread damage to WASH infrastructure in the Gaza Strip. *PLOS Global Public Health*, 5(2), e0004221. https://doi.org/10.1371/journal.pgph.0004221
39. Altahaan, Z., & Dobslaw, D. (2024). Assessment of the impact of war on concentrations of pollutants and heavy metals in aquatic environments: A review. *Environments*, 11(1), 10. https://doi.org/10.3390/environments11010010
40. UNICEF. (2017). *WASH assessment at the household level in the Gaza Strip*. United Nations Children's Fund and Gruppo di Volontariato Civile. https://www.unicef.org/sop/sites/unicef.org.sop/files/2018-08/GVC_WASH_Assessment_at_HH_Level_in_the_GS_final_0.pdf
41. Ali, T. (2026). Cesspits in the Gaza Strip: A long-term environmental and health disaster. *Ultra Palestine* (June 22, 2026). https://ultrapal.ultrasawt.com/
42. Tayeh, B. A., Alaloul, W. S., & Alnairab, A. F. (2019). Challenges facing municipalities to provide wastewater services: A case study of Gaza Strip. *International Conference on Sustainable Infrastructure 2019*, 428–440.
43. Fayad, M., Barrington, D. J., & Zaqout, M. (2025). The political economy of water and sanitation in Palestine's Gaza Strip: A scoping review. *PLOS Water*, 4(12), e0000418.
44. Görnt, A., Wilkes, T., Seelig, A., Sempert, T., Brasse, G., Maier, R., ... & Ruhl, A. S. (2025). Chemical and microbial similarities and heterogeneities of wastewater from singlehousehold cesspits for decentralised water reuse. *Water Reuse*, 15(2), 255–270.
45. Hasan, A. R., Hussein, M. A., Jafar, H. A., & Hussein, A. I. (2021). Septage characterization and sustainable fecal sludge management in rural Nablus–Palestine. *Sustainable Solutions for Environmental Pollution: Waste Management and Value-Added Products*, 1, 375–416.
46. Oduah, U. I., & Ogunye, E. B. (2023). A smart solution for preventing environmental pollution caused by overflowing onsite sewage septic tank. *Heliyon*, 9(5), e14925. https://doi.org/10.1016/j.heliyon.2023.e14925
47. Sekgobela, J. M., Khabo-Mmekoa, C. M., & Momba, M. N. B. (2024). Tracking enteric pathogen contamination from on-site sanitation facilities to groundwater in selected rural areas of Vhembe District Municipality, Limpopo Province, South Africa. *Heliyon*, 10(6), e27271. https://doi.org/10.1016/j.heliyon.2024.e27271
48. Alabi, O. A., Pasa, T. B. C., & Adebo, T. C. (2023). Environmental contamination and public health effects of household hazardous waste. *Journal of Environmental Pollution and Human Health*, 11(2), 22–31.
49. Yassin, M. M., & Abd Rabou, A. N. (2002). Perception of sludge use among farmers in Northern Governorate, Gaza Strip. *Bulletin of Faculty of Agriculture, Cairo University*, 53(4), 517-530.
50. Yassin, M. M., Tubail, K. M., & Al-Dadah, J. Y. (2008). Towards strategies for pollution control on the use of wastewater effluent in sustainable agriculture in the Gaza Strip. *World Review of Science, Technology and Sustainable Development*, 5(1), 66–78.
51. El-Sobaiehi, H. N. (2017). *Parasitic infection among farmers dealing with treated wastewater in Al-Zaitoun Area, Gaza City* [Doctoral dissertation, Al-Quds University].
52. Antić, I., Škrbić, B. D., Matamoros, V., & Bayona, J. M. (2020). Does the application of human waste as a fertilization material in agricultural production pose adverse effects on human health attributable to contaminants of emerging concern? *Environmental Research*, 182, Article 109132.
53. Abd Rabou, A. N. (2005). *An ecological survey and assessment of Wadi Gaza Nature Reserve, Gaza Strip – Palestine, with particular emphasis on wildlife* [Ph.D. Thesis, Department of Environmental Studies, School of Life Sciences, Faculty of Science and Technology, AlNeelain University, Sudan].
54. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Ali, A. S., & Hamad, D. M. (2007). Aspects of inhabitants' ecological knowledge on Wadi Gaza. *International Conference "Energy and Environmental Protection in Sustainable Development"*, University Graduates Union Hebron Governorate / Palestine, Palestine Polytechnic University (PPU), May 8-10, 2007.
55. Abd Rabou, A. N. (2026). Environmental Impacts of Israel's Ongoing War of Genocide and Ethnic Cleansing (2023–2026) on the Marine Ecosystem of the Gaza Strip, Palestine. *Examines in Marine Biology & Oceanography*, 8(2). In Press.

56. El-Kichaoi, A. Y., Abd Rabou, A. N., Sharif, F. A., & Al-Amassi, H. M. (2004). Changing trends in frequency of intestinal parasites in Gaza Strip, 1995 - 2000. *Journal of the Islamic University of Gaza (Natural Sciences Series)*, 12(2), 121-129.
57. Mezeid, N., Shaldoum, F., Al-Hindi, A. I., Mohamed, F. S., & Darwish, Z. E. (2014). Prevalence of intestinal parasites among the population of the Gaza Strip, Palestine. *Journal of the Egyptian Society of Parasitology*, 44(3), 281–289.
58. Al-Hindi, A. I., Redwan, A., El-Egla, G., Abu Qassem, R., & Alshammari, A. (2019). Prevalence of intestinal parasitic infections among university female students, Gaza, Palestine. *Avicenna Journal of Medicine*, 9(4), 143–147.
59. Mitchell, P. (2017). Intestinal parasites in the cesspool. *Journal of Paleopathology*, 29(2), 45–52.
60. Mitchell, P. D., & Tepper, Y. (2007). Intestinal parasitic worm eggs from a Crusader period cesspool in the city of Acre (Israel). *Levant*, 39(1), 91–95.
61. Eskew, W. H., Ledger, M. L., Lloyd, A., Pyles, G., Gosker, J., & Mitchell, P. D. (2019). Intestinal parasites in an Ottoman period latrine from Acre (Israel) dating to the early 1800s CE. *The Korean Journal of Parasitology*, 57(6), 575–581.
62. Abd Rabou, A. N., Yassin, M. M., Sharif, F. A., Al-Agha, M. R., Abu Daher, K. S., Ali, A. S., & Hamad, D. M. (2008). Inhabitants' knowledge on mosquito proliferation and control in the wetland ecosystem of Wadi Gaza, Gaza Strip, Palestine. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 16(2), 41-61.
63. Kenawy, M. A., Ammar, S. E., & Abdel-Rahman, H. A. (2013). Physico-chemical characteristics of the mosquito breeding water in two urban areas of Cairo Governorate, Egypt. *Journal of Entomological and Acarological Research*, 45(3), 17–23.
64. Osborne, P. J. (1983). An insect fauna from a modern cesspit and its comparison with probable cesspit assemblages from archaeological sites. *Journal of Archaeological Science*, 10(5), 453–463.
65. Abd Rabou, A. N. (2026). Medically and Public Health–Important Arthropods in Gaza Strip Displacement Camps during the Israeli War (2023–2026): Documented and Potential Occurrence, Ecological Drivers, Health Risks, and Humanitarian Implications. *Journal of Diversity Studies*, 5(2), 112-127. https://doi.org/10.51470/JOD.2026.5.2.112
66. Abd Rabou, A. N. (2026). Control Measures for Commensal Rodent Infestations in the Gaza Strip, Palestine, during Israel's Ongoing War of Genocide and Ethnic Cleansing (2023–2026). *Journal of Diversity Studies*, 5(2), 143-157. https://doi.org/10.51470/JOD.2026.5.2.112
67. Al-Hindi, A. I., & Abu-Haddaf, E. (2013). Gastrointestinal parasites and ectoparasites biodiversity of *Rattus rattus* trapped from Khan Younis and Jabalia in Gaza Strip, Palestine. *Journal of the Egyptian Society of Parasitology*, 43(1), 259–268.
68. Abd Rabou, A. N., Elhabiby, M. I., Gafar, M. F., Alfera, Y. M., El-Hindi, M. W., Ibrahim, Y. K., AlBanna, M. S., Idais, R. H., Tanboura, A. A., Alsalibi, T. M., Qaraman, A. A., Al-Agha, M. R., Abd Rabou, M. A., Dardona, A. W., Shawa, S. S., Abd Rabou, O. A., Tayeh, B. A., Rabah, F. K., Abualtayef, M. T., Abd Rabou, A. A., & Yassin, M. M. (2026). Vertebrate Pest Outbreaks in Gaza Displacement Camps under Conditions of Israeli War of Genocide and Ethnic Cleansing (2023–2026): Ecological Drivers, Public Health Risks, and Humanitarian impacts. *Journal of Diversity Studies*, 5(2), 5-22. https://doi.org/10.51470/JOD.2026.5.2.05
69. OSHA – Occupational Safety and Health Administration (2015). *Trenching and excavation safety* (OSHA Publication No. 2226-10R 2015). U.S. Department of Labor. https://www.osha.gov/sites/default/files/publications/OSHA2226.pdf
70. NIOSH (1994). *Worker deaths in confined spaces: A summary of NIOSH surveillance and investigative findings* (DHHS/NIOSH Publication No. 94-103). National Institute for Occupational Safety and Health. https://doi.org/10.26616/NIOSHPUB94103
71. Afifi, S. (2006). Wastewater reuse status in the Gaza Strip, Palestine. *International Journal of Environment and Pollution*, 28(1-2), 76–86.
72. Abu Madi, M., Al-Sa'ed, R., Mahmoud, N., & Burnat, J. (2010). *Comparative socioeconomic study of greywater and cesspit systems in Ramallah, Palestine*. Practical Action Publishing.
73. Mahmoud, N., & Mimi, Z. (2011). Assessment of non-conventional source separated grey wastewater treatment and agricultural reuse in Palestinian rural areas. *Cross-Country Assessment of Urban Ecosan Systems*, 14–29.
74. Afifi, S., Legesse, N. B., Arakelyan, K., Nassar, A. M., & Wise, T. (2013). *Using reed bed system for wastewater treatment and reuse in urban semi/urban community in Gaza Palestine*. Research Report.
75. Afifi, S., Alnahhal, S., & Abdelall, S. (2015). Developing an integrated sustainable sanitation system for urban areas: Gaza Strip case study. *Procedia CIRP*, 26, 767–774.
76. Alnajjar, H. Y. (2023). The sustainability of wastewater treatment efficiency and its estimated impact for onsite wastewater treatment plant systems in semi-urban areas: A Khan Yunis case study. *Desalination and Water Treatment*, 287, 29–38.
77. Murebwayire, M. L., Nilsson, E., Wali, U. G., & Nhapi, I. (2026). A compliance assessment tool for household pit latrines and cesspits against RS ISO 24521: Evidence from Kigali City. *Frontiers in Public Health*, 14, Article 1795680.