



Assessment of Environmental and Public Health Risks of Unregulated Solid Waste Dumping: A Case Study of the Sidi Khalifa Temporary Landfill in Benghazi, Libya

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تقييم المخاطر البيئية والصحية العامة الناجمة عن التخلص غير المنظم من النفايات الصلبة: دراسة حالة المكب المؤقت في منطقة سيدي خليفة، بنغازي – ليبيا

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Abstract

This study investigates the environmental and public health impacts of unregulated solid waste dumps in Benghazi, Libya, focusing on the Sidi Khalifa temporary landfill. Utilizing a mixed-method approach, including field surveys, interviews, and statistical analysis (SPSS), data were collected from 100 residents living near and far from the landfill. Results indicate significant environmental degradation, including air pollution from methane emissions (65% of respondents), foul odors (63%), and soil/water contamination (46–48%). Health impacts include respiratory issues (49%), frequent influenza (55%), and eye irritation (41%). Proximity to the landfill exacerbated these issues, with residents within 1 km reporting higher disease prevalence. The study underscores the urgent need for improved waste management policies, public awareness campaigns, and infrastructure development to mitigate risks. Recommendations emphasize stricter regulations, recycling initiatives, and community education to align with sustainable development goals.

Keywords: Solid waste management, environmental pollution, public health, landfill impacts, Benghazi, Libya.

الملخص

تتناول هذه الدراسة التأثيرات البيئية والصحية العامة لمكبات النفايات الصلبة غير المنظمة في مدينة بنغازي، ليبيا، مع التركيز على المكب المؤقت في منطقة سيدي خليفة. استخدمت الدراسة منهجاً مختلطاً شمل المسوحات الميدانية، والمقابلات، والتحليل الإحصائي باستخدام برنامج SPSS، حيث تم جمع البيانات من 100 من السكان القاطنين بالقرب والبعيد عن المكب. أظهرت النتائج وجود تدهور بيئي كبير، بما في ذلك تلوث الهواء نتيجة انبعاثات الميثان (65% من المشاركين)، والروائح الكريهة (63%)، وتلوث التربة والمياه (بنسبة تتراوح بين 46–48%). كما تم تسجيل آثار صحية

سلبية شملت مشكلات تنفسية (49%)، وتكرار الإصابة بالإنفلونزا (55%)، وتهيج العين (41%). وُجد أن القرب من المكب يزيد من حدة هذه المشكلات، حيث أبلغ السكان المقيمون ضمن نطاق كيلومتر واحد عن نسب أعلى من انتشار الأمراض. تؤكد الدراسة على الحاجة الملحة لتحسين سياسات إدارة النفايات، وإطلاق حملات توعية عامة، وتطوير البنية التحتية للحد من هذه المخاطر. وتوصي الدراسة بتشديد اللوائح، وتفعيل مبادرات إعادة التدوير، وتثقيف المجتمع بما يتماشى مع أهداف التنمية المستدامة.

الكلمات المفتاحية: إدارة النفايات الصلبة، التلوث البيئي، الصحة العامة، تأثيرات المكبات، بنغازي، ليبيا.

Introduction

Urbanization and population growth are primary drivers of escalating solid waste generation, posing severe management challenges for municipalities globally. In developing nations like Libya, inadequate infrastructure exacerbates environmental and health risks, particularly near unregulated landfills. This study focuses on Benghazi's Sidi Khalifa landfill—established as a temporary site in 2014 but still operational—assessing its impacts on air, water, soil, and public health, alongside socio-economic factors influencing waste generation (0.3–1.0 kg/person/day).

Globally, improper solid waste management (SWM) contributes 5% of greenhouse gas emissions (chiefly methane) and groundwater contamination. In Benghazi, proximity of landfills to residential areas disproportionately affects vulnerable populations, aligning with UN SDGs 3 (Health) and 11 (Sustainable Cities). Prior research underscores these risks: Salam Abul (2010) correlated dumpsite proximity in Eswatini with malaria and cholera outbreaks, while Palestinian studies (2001) highlighted groundwater pollution from mixed waste. In Libya, Badi et al. (2017) identified organic waste (59%) as dominant, yet composting and waste-to-energy potential (Hamad et al., 2014) remain untapped. This study bridges gaps in local policy and community awareness, offering evidence to guide sustainable SWM strategies in Benghazi and similar contexts.

1. Aim

To assess the environmental and public health risks caused by the unregulated Sidi Khalifa solid waste landfill in Benghazi, Libya.

2. Materials and Methods

2.1. Study Area

The study area is located in Benghazi, the second largest city in Libya. It overlooks the Mediterranean coast and has a radial city plan centered on Lake Benghazi in the city center. Greater Benghazi includes cities and towns in its south, such as Qaminis, Suluq, Al-Abyar, and Tocra. In addition to being the largest city in eastern Libya, its recorded population was 500,120 in the 1995 census, rising to 670,797 in the 2006 census. It contains a large number of random solid waste dumps, with almost every residential area containing a random solid waste dump. In addition to the city's main dump in the Qanfouda area and the temporary dump in the Sidi Khalifa area, this study selected the largest random solid waste dump in terms of area and construction period. 2014.



Figure:1 Study area: Benghazi city.

2.2. Sidi Khalifa Landfill:

Since the beginning of 2005, the Sidi Khalifa area has witnessed unprecedented architectural development due to the displacement of most of Benghazi's population. This has led to a rise in land and rent prices, and has led to a marked improvement in the standard of living of the area's residents. It has also witnessed significant development in communications and technology. Sidi Khalifa is a suburb located 17 km north of Benghazi. It is an agricultural and industrial suburb and one of the 37 districts of the Benghazi Municipality. This landfill was established in 2014 during the Battle of Karama, when the city's main landfill was closed. This new landfill was created as a temporary one, but it remains in operation until the present (the study period).



Figure:1 Sidi Khalifa landfill.

2.3 Data Collection

2.3.1 Sampling Strategy

A stratified random sampling technique was employed to ensure representative data from varying proximities to the landfill. A total of 100 households participated in the study, divided equally into two strata: 50 households located within 1 kilometer of the Sidi Khalifa landfill ("near"), and 50 households situated beyond 1 kilometer ("far").

2.3.2 Data Collection Instruments

Data were gathered using structured questionnaires designed to capture a range of variables, including demographic characteristics, environmental perceptions, health-related symptoms, and socio-economic impacts. The reliability of the questionnaire was confirmed with a Cronbach's alpha value of 0.86, indicating high internal consistency.

2.3.3 Temporal Scope

Data collection was conducted over a two-month period, from January to February 2024.

2.4 Data Analysis

Descriptive and inferential statistical analyses were performed using SPSS version 28. Comparative assessments were made between responses from households near and far from the landfill, as well as by duration of residency, to identify patterns and statistically significant differences.

3. Results

3.1 Demographic Profile

- **Gender and Marital Status:** 89% of respondents were male, and 54% were married.
- **Education Level:** 33% had completed secondary education.
- **Residency Duration:** 35% had lived in the area for 6–10 years.

3.2 Environmental Impacts

- **Air Pollution:**
 - 65% of respondents reported severe odors attributed to methane emissions.
 - 63% reported persistent foul smells in the vicinity.
- **Water and Soil Contamination:**
 - 48% observed moderate levels of water pollution.
 - 46% noted visible soil degradation, likely due to leachate and unmanaged waste disposal.

3.3 Health Impacts

Respiratory Symptoms:

49% of participants reported experiencing chest pain.
 55% indicated frequent occurrences of influenza-like symptoms.

Other Health Issues:

41% reported eye irritation.
 Less than 10% reported more severe conditions such as cancer or kidney disease.

3.4 Socio-Economic Effects

1. 87% of respondents expressed concern over long-term health risks linked to landfill exposure.
2. 51% believed that the presence of the landfill negatively impacted property values.
3. 80% reported frequent pest infestations, particularly flies and rodents, as a direct consequence of poor waste management.

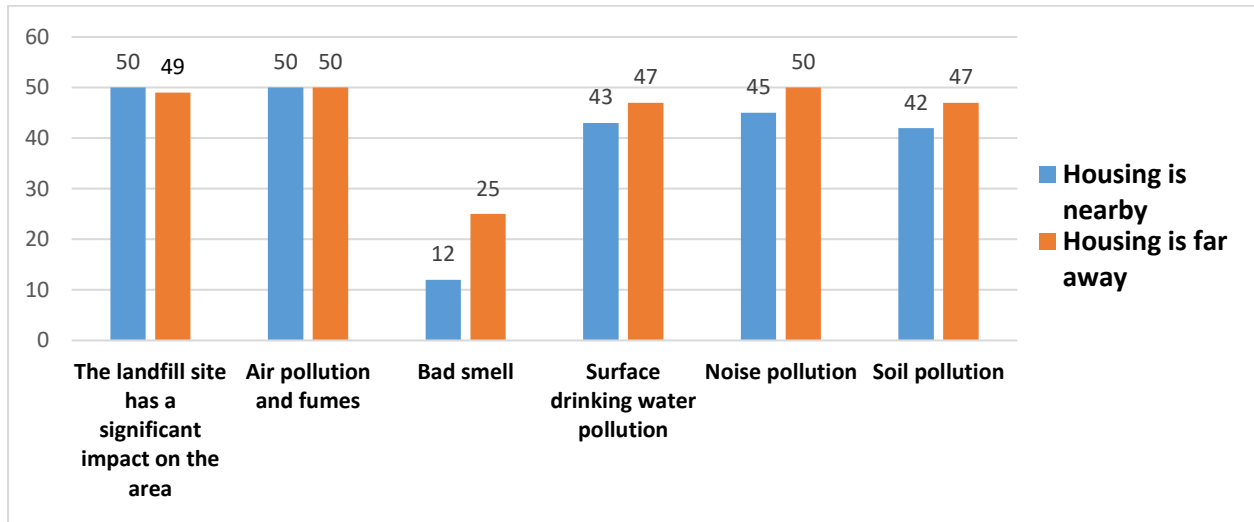


Figure: 3 Comparison of Environmental Impacts Perceived by Residents Living Near and Far from a Landfill Site.

Description of Figure (3): This bar chart compares the perceptions of environmental impacts between two groups: residents living near a landfill site (blue bars) and those living far from it (orange bars). The chart evaluates six different environmental impact indicators:

1. Perceived overall impact of the landfill site on the area
2. Air pollution and fumes
3. Bad smell
4. Surface drinking water pollution
5. Noise pollution
6. Soil pollution

Data Analysis:

- **The landfill site has a significant impact on the area:** Both groups (nearby: 50, far: 49) show almost equal agreement on the landfill's significant impact.
- **Air pollution and fumes:** Both groups rated this equally (50), indicating a shared concern regardless of distance.
- **Bad smell:** Residents far from the landfill reported a much higher concern (25) compared to those living nearby (12), which is unexpected and suggests potential issues in odor dispersion or subjective perception.
- **Surface drinking water pollution:** Those farther away reported more concern (47) than those nearby (43).
- **Noise pollution:** More residents living far from the landfill reported noise pollution (50) than nearby residents (45).
- **Soil pollution:** Again, those farther from the landfill expressed slightly more concern (47) than those nearby (42).

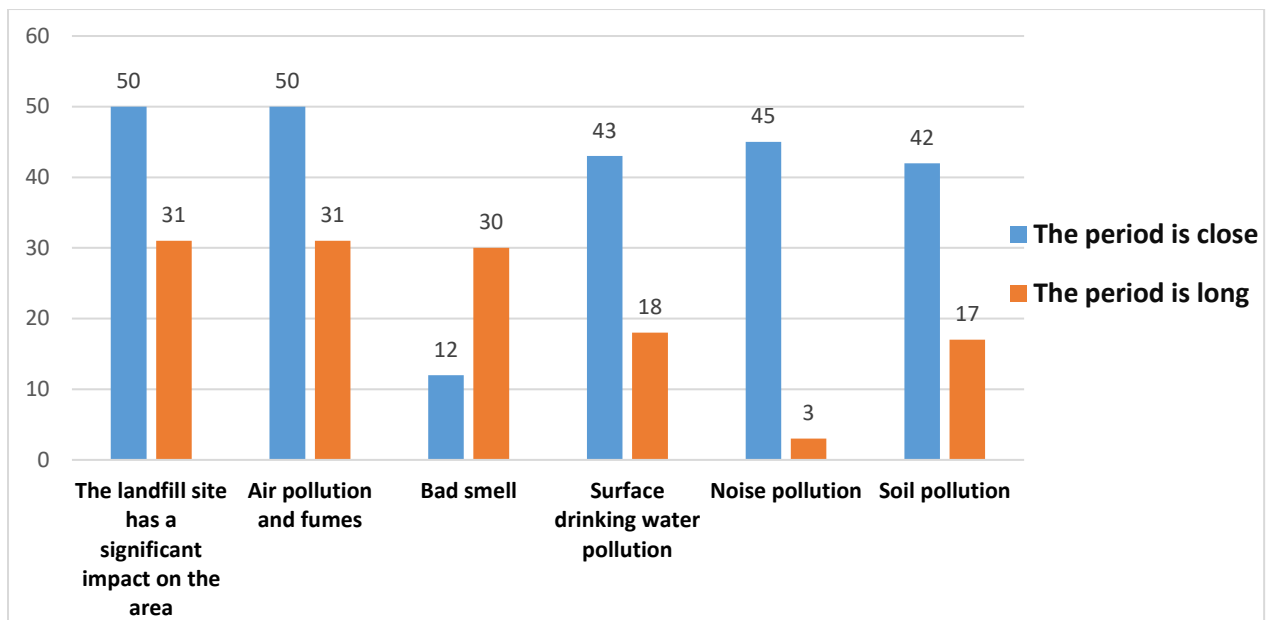


Figure:4 Perceived Environmental Impacts of the Landfill Site Based on Duration of Residence (Short vs. Long Period).

Description of Figure (4) This bar chart compares perceptions of environmental impacts among two groups of residents based on how long they have lived near a landfill site:

- **Blue bars** represent those who have lived in the area for a **short period** ("The period is close").
- **Orange bars** represent those who have lived in the area for a **long period** ("The period is long").

The chart covers six categories:

1. The landfill site has a significant impact on the area
2. Air pollution and fumes
3. Bad smell
4. Surface drinking water pollution
5. Noise pollution
6. Soil pollution

Data Analysis:

- **Significant Impact:** 50 respondents who recently moved in report a strong perceived impact, while only 31 of long-term residents agree, suggesting that newer residents might be more sensitive or aware.
- **Air Pollution and Fumes:** Equal trend as above (50 vs. 31), indicating recent residents perceive higher air quality issues.
- **Bad Smell:** Long-term residents (30) are more likely to report unpleasant odors than newer ones (12), possibly due to prolonged exposure or cumulative effects.
- **Surface Drinking Water Pollution:** A higher percentage of newer residents (43) perceive this issue than long-term residents (18), potentially due to initial perceptions or awareness.
- **Noise Pollution:** A stark contrast—newer residents (45) report significantly more noise issues compared to only 3 long-term residents, suggesting adaptation or desensitization over time.
- **Soil Pollution:** Reported more by newer residents (42) than long-term (17), again pointing to either increased awareness or reduced sensitivity among long-term inhabitants.

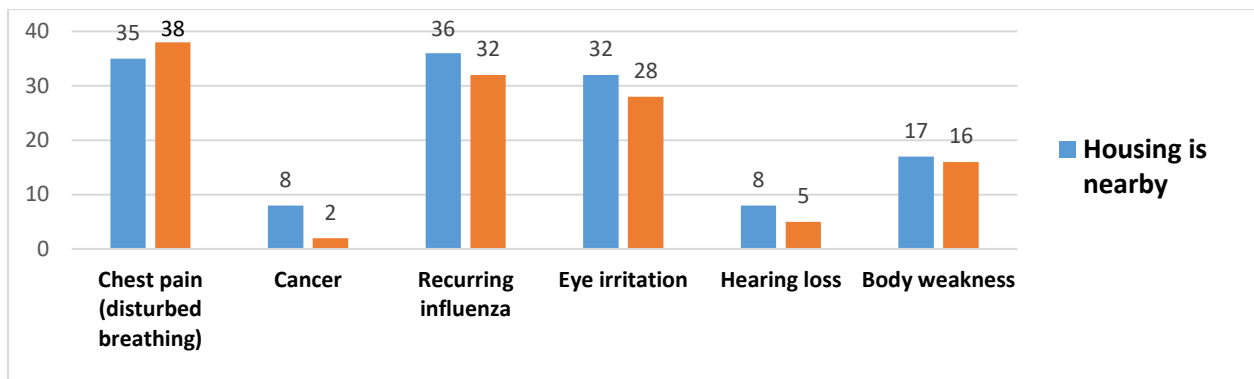


Figure:5 Health Issues and Proximity to Housing.

Description of Figure (5): The first graph presents two sets of numerical values (left and right columns) alongside labels indicating various health issues and housing proximity. The numbers likely represent frequencies, percentages, or severity scores related to each condition.

Key Observations:

- **Symmetrical Values:** Most entries have identical numbers on both sides (e.g., 40-38, 35-35, 30-30), suggesting a balanced or comparative analysis.
- **Health Conditions:** Listed issues include chest pain (disturbed breathing), cancer, recurring influenza, eye irritation, hearing loss, and body weakness.
- **Housing Proximity:** The last two entries distinguish between "Housing is nearby" and "Housing is far away," possibly indicating how distance affects health outcomes.

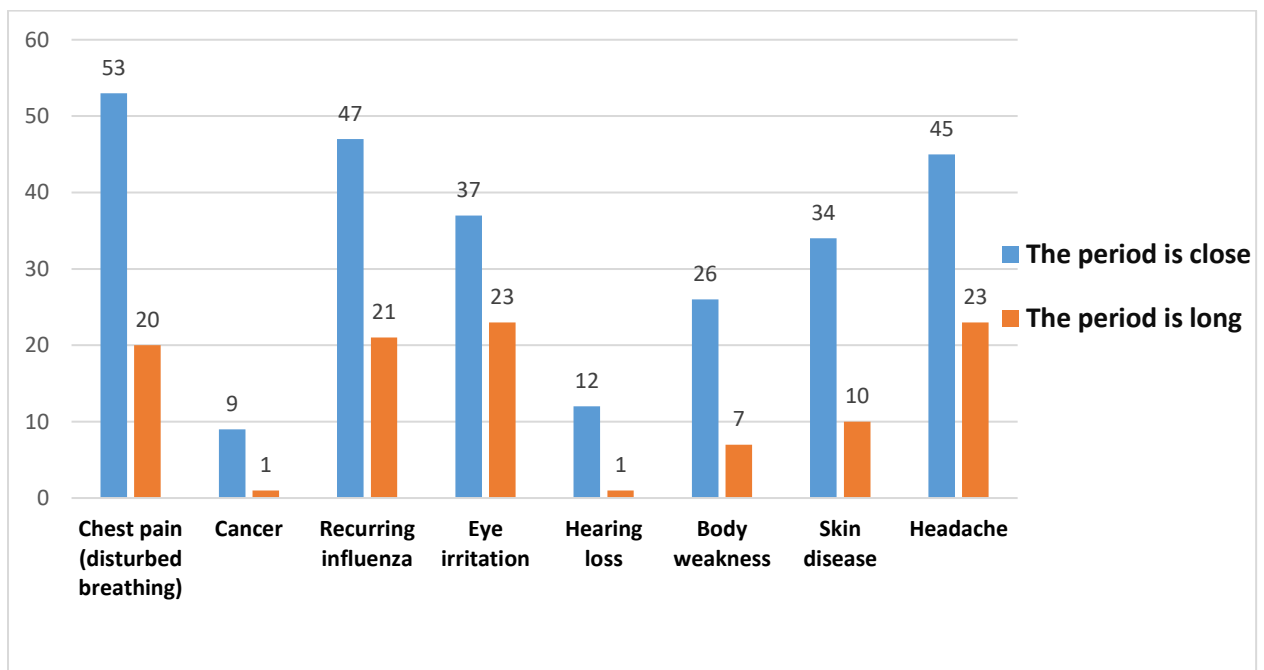


Figure:6 Housing-Related Concerns and Contamination Issues.

Description of Figure (6): The graph displays numerical values (e.g., 60, 50, 40) alongside labels related to housing, contamination, and social concerns. The numbers may represent severity, frequency, or survey responses.

- **Key Observations:**
- **Higher Values:** Peaks at 60 and 50 suggest significant concerns (e.g., "Fear for future health," "Property cannot be sold").
- **Repetition:** Phrases like "contamination" are repeated (fly, rodent, mosquito), emphasizing pollution as a major issue.
- **Social Impact:** Entries like "Friends unwilling to contact" and "Poor rental property" highlight broader societal effects.

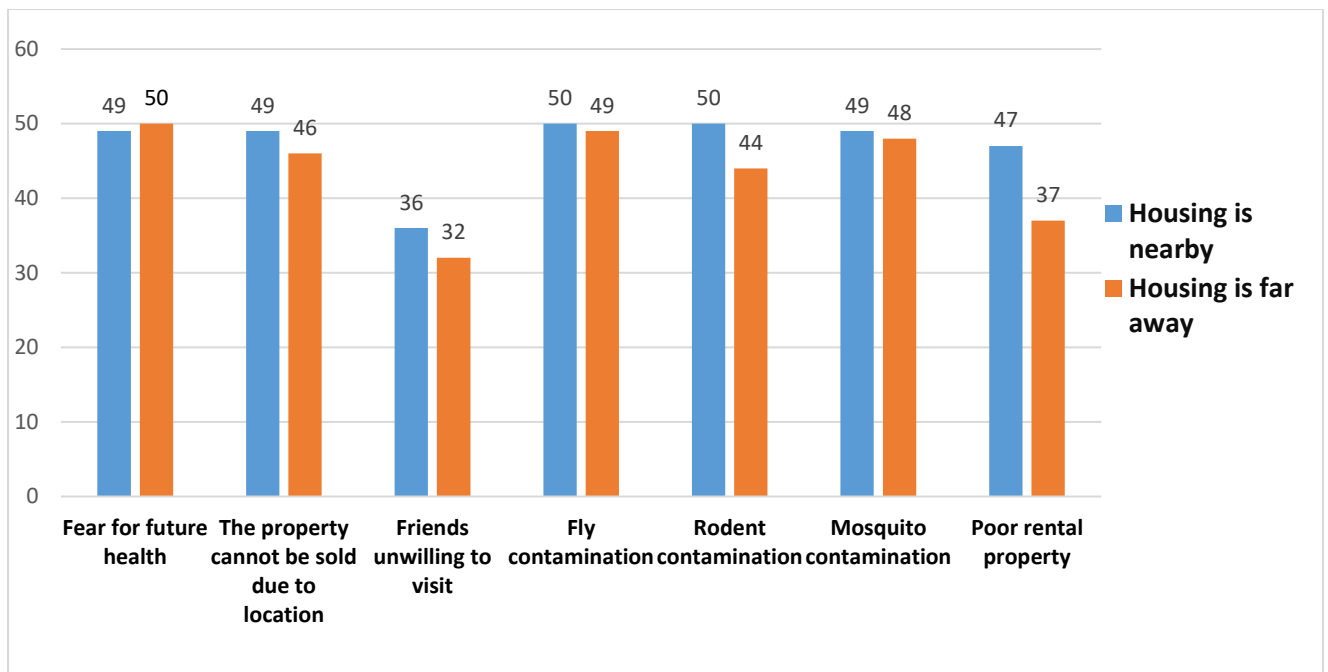


Figure:7 Impact of Housing Location on Property Concerns.

Description of Figure (7): The graph depicts two scenarios: "Housing is nearby" and "Housing is far away," with corresponding values representing different concerns related to property and living conditions.

- **Nearby Housing:** The highest value is 50, appearing twice, followed by 49 (three times), and then decreasing values (48, 47, 46, 36, 32).
- **The concerns listed include:** Fear for future health due to location, Property cannot be sold (unwilling to visit), Friends unwilling to contact, Fly, rodent, and mosquito contamination and Poor rental property.
- **Faraway Housing (Right Side):** Values are generally lower, with 44 and 37 being the highest. And Similar concerns are listed but with reduced frequency or severity.

Analysis: Proximity to housing increases reported concerns, particularly contamination and social reluctance. The repeated high values (49, 50) suggest strong negative perceptions when housing is nearby. Lower values for faraway housing indicate distance mitigates some concerns, though issues like contamination persist.

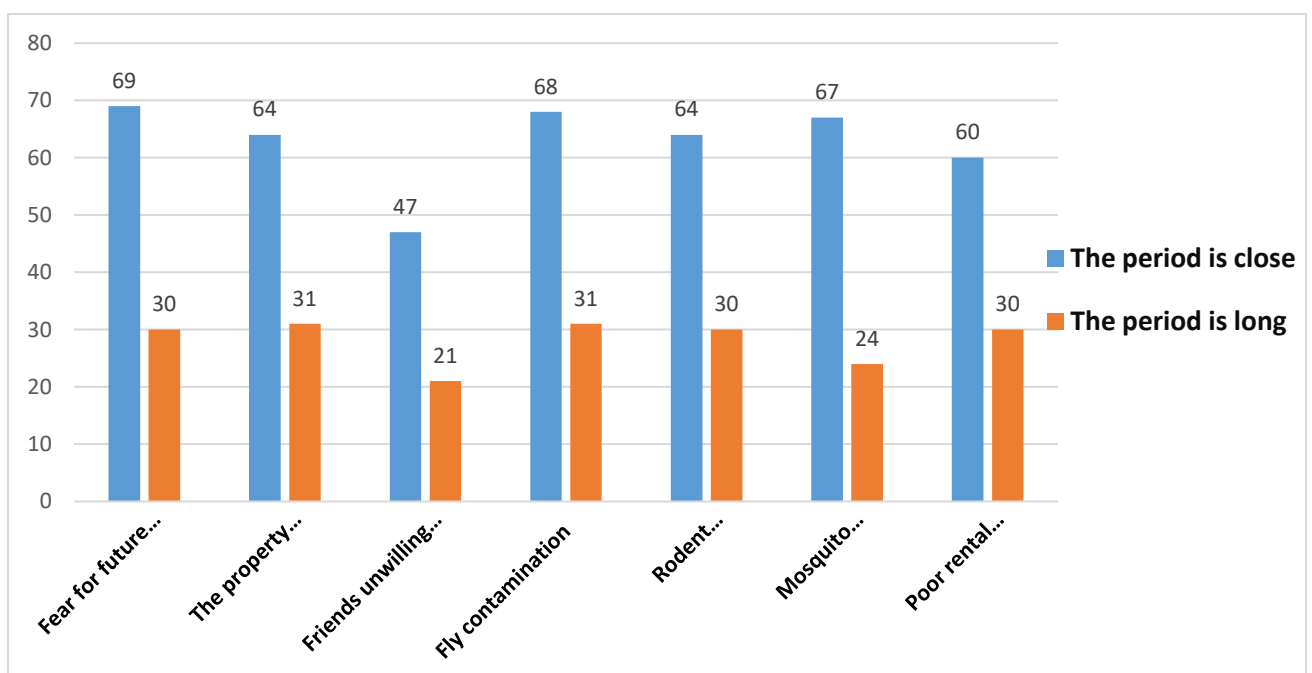


Figure:8 Property Concerns Over Time.

Description of Figure (8): The graph compares two time periods: "The period is close" and "The period is long," with varying values representing property-related concerns.

- **Close Period:** Values peak at **80**, followed by **69, 64, 47, 31, 21**. Concerns include fear for future health, property issues, social reluctance, and contamination (my, rodent, mosquito).
- **Long Period :** Values are lower, starting at **63, 64, 67, 60**, then dropping sharply to **30, 20, 10, 0**. Similar concerns are listed but with declining intensity over time.

Analysis: Immediate ("close") periods show heightened concerns, possibly due to recent events or acute issues. Over time ("long period"), concerns diminish, suggesting adaptation or resolution of problems. The sharp drop to **0** implies some issues may no longer be relevant in the long term.

3. Discussion

The Sidi Khalifa landfill's proximity to homes correlates strongly with respiratory and ocular ailments, aligning with global studies on landfill health risks (Abul, 2010). High methane emissions (65%) reflect inadequate waste segregation and organic decomposition, exacerbating climate impacts. Despite Libya's 2017 waste management policies, implementation remains weak, necessitating urgent reforms. Notably, residents living >1 km reported fewer health issues, highlighting distance as a protective factor. However, prolonged exposure (>10 years) intensified symptoms, emphasizing cumulative risks.

Discussion of Figure (3): The results reveal some interesting patterns. While one might expect that those living near the landfill would report greater environmental concerns, in several categories (bad smell, surface water, noise, and soil pollution), residents farther from the landfill expressed more concern. This could be due to various factors, such as prevailing wind directions, water flow patterns, awareness levels, or psychological perceptions. Only in the category of bad smell is the difference notably large, with distant residents reporting twice the level of concern. This anomaly could merit further investigation, potentially examining topographical or meteorological influences.

Although proximity to the landfill is expected to correlate with heightened environmental concern, this data suggests the need for more nuanced studies to understand public perception and actual environmental impact. Education and communication with both nearby and distant communities may help align perceptions with measured environmental risks.

Discussion of Figure (4): The data suggests that the **duration of residence** significantly influences environmental risk perception. **Newer residents** are consistently more likely to perceive environmental hazards such as air and water pollution, noise, and soil contamination. In contrast, **long-term residents** report lower concern in most categories—potentially due to habituation, reduced sensitivity, or a shift in perception over time. The **exception** is the **bad smell**, where long-term residents report greater concern. This may reflect the cumulative exposure over the years, or it might indicate a worsening problem not initially present when newer residents arrived.

Perceptions of environmental impacts from the landfill differ notably between new and long-term residents. These results underscore the importance of considering **residence duration** when assessing community responses to environmental issues. Awareness campaigns and monitoring should be tailored accordingly—addressing both the heightened concerns of newer residents and the possible underestimation by long-term residents.

Discussion of Figure (5) The symmetry in numbers may imply a controlled study comparing two groups (e.g., nearby vs. far housing), Chest pain and cancer show slight disparities (40 vs. 38, 32 vs. 32), while other conditions like influenza and eye irritation have perfect matches and The lower values (e.g., 5-5, 8-8) suggest less frequent or severe issues like hearing loss or body weakness.

The graph likely compares health impacts based on housing proximity, showing minor variations in certain conditions. Further context is needed to determine causality (e.g., pollution, healthcare access).

Discussion of Figure (6) The graph may depict resident complaints or survey data on housing quality and environmental hazards. Contamination (flies, rodents, mosquitoes) is a recurring theme, indicating poor sanitation and Economic concerns ("Property cannot be sold") and social isolation ("Friends unwilling to contact") suggest multifaceted housing crises.

The data underscores severe housing-related problems, particularly contamination and social stigma. Interventions should address sanitation and community engagement.

Discussion of Figure (7): Possible reasons for higher concerns nearby: noise, pollution, or perceived lower property value. Social factors (friends unwilling to visit) may relate to stigma or discomfort with the area. Contamination issues (flies, rodents, mosquitoes) likely stem from poor maintenance or environmental factors.

Housing proximity significantly influences concerns about health, property value, and social interactions. Addressing contamination and improving neighborhood conditions could reduce negative perceptions.

Discussion of Figure (8): High initial values may reflect panic or recent negative experiences (e.g., infestation, bad tenant experiences).

Decline over time could indicate: Effective problem-solving (e.g., pest control). Psychological adjustment (residents becoming accustomed to conditions). And Property improvements or policy changes.

Property concerns are most intense in the short term but decrease over time. Proactive measures in early stages could mitigate long-term dissatisfaction.

4. Conclusion

Unregulated landfills in Benghazi pose severe environmental and health threats, disproportionately affecting nearby residents. The Sidi Khalifa case underscores systemic failures in waste governance, requiring multi-sectoral interventions.

5. Recommendations :

1. Policy Enforcement: Strict regulations for waste segregation and landfill engineering .
2. Public Awareness: Community workshops and media campaigns on recycling and health risks .
3. Infrastructure Investment: Develop composting/recycling facilities outside residential zones .
4. Research: Longitudinal studies to monitor landfill-related diseases.

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