Journal of Environment Pollution and Human Health, 2025, Vol. 13, No. 3, 50-60
Available online at http://pubs.sciepub.com/jephh/13/3/3
Published by Science and Education Publishing
DOI:10.12691/jephh-13-3-3

Environmental Pollution and Health Vulnerability in the Municipality of Natitingou in Northwest Benin: Analysis of Hygiene and Sanitation Practices in the Context of Climate Change

SANGA PEMA Tébouwa Gislaine[1,*], KADJEGBIN Toundé Roméo Gislain[2], KIARI FOUGOU Hadiza[3]

[1]FLASH Multidisciplinary Doctoral School, University of Abomey-Calavi, Benin
[2]Urban and Regional Dynamics Research Laboratory at the University of Abomey-Calavi, Benin
[3]University of Diffa in Niger
*Corresponding author: gispema@gmail.com

Received October 10, 2025; Revised November 12, 2025; Accepted November 20, 2025

Abstract Poor hygiene raises concerns about soil and groundwater contamination in the municipality of Natitingou. Climate change is exacerbating challenges related to pollution and public health. This research explores environmental pollution and health vulnerability related to hygiene and sanitation practices in the municipality of Natitingou. Economic and health data have been analyzed with appropriate statistical tools (index and ratio). In addition, 271 people have been surveyed. SPSS 17.0 and ArcGIS 10.3 software have been used to process the data. The results show that illegal dumpsites are widespread throughout all districts of the municipality of Natitingou. Dumpsites are most prevalent in the districts of Kotapounga, Perma, and Natitingou 3. The DAL rate is very high in Kotapounga (65%), Tchoumi-Tchoumi (64%), Kouaba (63%), Kouandata (60%), and Perma (60%). Increasingly frequent flooding overwhelms sanitation systems (latrines, septic tanks), scattering pathogens and pollutants into the environment. This heightens people's vulnerability to disease. Poorly managed waste and stagnant water favors mosquito breeding and other vectors of climate-sensitive diseases, such as ARIs and diarrheal diseases. In fact, low acute respiratory illnesses in the municipality of Natitingou have risen from 7,856 in 2003 to 9,156 in 2024, with a peak of 11,564 in 2006.

Keywords: *Municipality of Natitingou, environmental pollution, hygiene, and sanitation*

Cite This Article: SANGA PEMA Tébouwa Gislaine, KADJEGBIN Toundé Roméo Gislain, and KIARI FOUGOU Hadiza, "Environmental Pollution and Health Vulnerability in the Municipality of Natitingou in Northwest Benin: Analysis of Hygiene and Sanitation Practices in the Context of Climate Change." *Journal of Environment Pollution and Human Health*, vol. 13, no. 3 (2025): 50-60. doi: 10.12691/jephh-13-3-3.

1. Introduction

Water, hygiene, and sanitation are key to community development, better health, and increased economic productivity everywhere [1]. Like education and health, they are also vital in fighting poverty [2]. Protecting people's surroundings requires attention to two environmental indicators: hygiene and sanitation [3]. Both contribute to environmental health. Hygiene and sanitation are sometimes lacking in some countries around the world, leading to significant human health issues [4]. A further 4.5 billion people (source), or 60% of the world's population, do not have access to safely managed sanitation services. Environmental issues are now a major concern for all countries around the world, due to the degradation of natural resources and the living environment [5]. Several international summits and conferences have been held, namely in Stockholm (Sweden) in 1972, Rio de Janeiro (Brazil) in 1992, and Johannesburg (South Africa) in 2002. Africa is no exception to the resolutions reached at these summits and conferences [6]. Maintaining and improving people's health are closely linked. This hygiene requires both individual and collective efforts, as well as specific attitudes and behaviors. Human communities often establish rules based on their perceptions and resources [7]. For example, diarrhea is a major cause of death among children under five in Benin [8]. These issues stem from insufficient compliance with hygiene rules, a lack of environmental awareness, such as defecating in fields, forests, bushes, bodies of water, or other open spaces, or disposing of feces with solid household waste, which leads to unsafe drinking water and waterborne diseases [9]. Weather events in Benin damage or destroy sanitation infrastructure, including latrines, sewer systems, and wastewater treatment plants. This may result in environmental contamination and increased health risks [10]. Changes in rainfall patterns affect solid and liquid

waste management. Flooding disperses waste. Droughts impede proper waste disposal [11]. Shifts in temperature and precipitation can affect the distribution and abundance of disease vectors such as mosquitoes and flies. This can lead to an increased risk of vector-borne diseases [12].

With its demographic explosion, the municipality of Natitingou is no exception to the rule, as unsanitary conditions continue to worsen. As a result, sanitation is becoming increasingly difficult for city dwellers, even though it is a necessary and vital service not only for their well-being, but also for the smooth running and efficiency of the urban economy. Climate change exacerbates challenges related to pollution and public health. They affect water availability and quality, as well as the frequency of climate-sensitive diseases. This research aims to analyze environmental pollution and health vulnerability related to hygiene and sanitation practices in the municipality of Natitingou.

2. Materials et Methods

2.1. Scope of the study

Located in northwest Benin in the center of the Atacora department, the municipality of Natintingou lies between 10°0' and 10°25' north latitude and between 1°10' and 1°35' east longitude. It is bordered to the north by the municipality of Toucountouna, to the east and southeast by the municipality of Kouandé, to the southwest by the municipality of Copargo, and to the west by the municipality of Boukombé. It covers an area of 3,045 km², i.e., 12.8% of the department's total area. Natitingou has 76 villages and urban districts spread across nine (09) districts, including three (03) urban districts, Natitingou 1, Natitingou 2, and Natitingou 3, and six (06) rural districts, Perma, Kouandata, Tchoumi-Tchoumi, Kotopounga, Péporiyakou, and Kouaba [13]. Located in a valley at the foot of the Atacora mountain range, this municipality features plateaus and hills in some areas, creating significant challenges for hygiene and sanitation. The rugged terrain makes wastewater drainage and solid waste management systems less effective. Figure 1 shows the geographical location of the municipality of Natitingou.

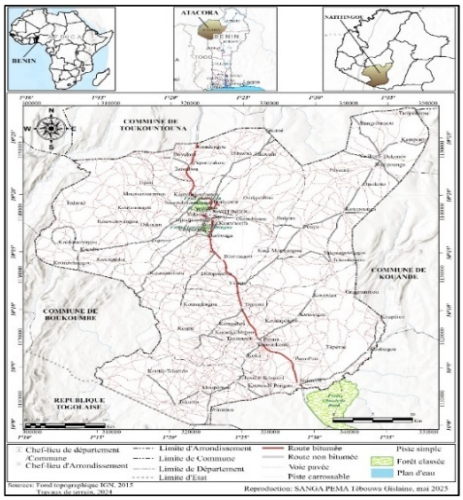


Figure 1. Geographical and administrative location of the municipality of Natitingou

2.2. Research Methodology

This research involves collecting data, processing it, and analyzing the results.

2.2.1. Data Used

This research employs various data types: climate data such as annual rainfall levels and temperatures in the municipality of Natitingou for the period 1981-2023, extracted from Meteo-Benin files; soil data enabling analysis of the physical assets, statistical data on the population of the municipality of Natitingou from 1979 to 2013 collected from the National Institute of Statistics and Demography (INStaD), and sociodemographic data on households, especially the sociodemographic characteristics (household size, number of people per room) and measures taken by the authorities to raise awareness of hygiene and sanitation practices.

2.2.2. Data Processing

Descriptive statistics and statistical tests have been used to analyze the data. For qualitative variables, response frequencies have been calculated, while for quantitative variables, means and standard errors have been calculated. The databases are exported to SPSS version 17.0 for tabulation. SPSS software is chosen because it is one of many software programs specializing in data processing. Descriptive statistics are used to process the data once it has been entered and validated. Positive and negative response rates to a question are determined based on the actual score for each item in the questionnaire, not on the total number of respondents. The number of responses per question is expressed in terms of the statistical formula:

$$P_1 = \frac{n}{N} \text{X} 100 \quad (1)$$

where n is the number of people who respond positively and N is the sample size at the municipal level. Statistical processing involved calculating various rates, ratios, and indices.

- Water supply rate

The water infrastructure coverage rate is calculated based on the number of water points that are built and operational in the Commune's villages.

Tdx = (number of water points that are built and operational x 250/ $Population\ x$) x 100 (2)

where: Tdx = service coverage rate of the municipality x; Population x = total users x. Thus, 250 is the standard adopted by the WHO. Water supply equipment is provided to serve 250 users [14].

- Hygiene and sanitation infrastructure coverage rates

The hygiene and sanitation infrastructure studied include latrines, urinals, handwashing facilities, and trash cans.

TCi = (available sanitation infrastructure/number of needed infrastructure) x 100 (3)

TCi = Coverage rate in a given infrastructure. Each of the calculated rates is compared to the relevant standard, if available.

- Ratio

This study assesses the population-to-water point and population-to-toilet ratios in different villages using the following formula:

$R\ app/inf = N$number of people/ number of available infrastructures (4)

Each of the ratios calculated is compared with the relevant standard. The water samples for microbiological analysis are pre-selected due to the relatively high risk of contamination and the high frequency of consumption. The physical, chemical, and bacteriological analyses used for this study are those carried out by DG-Water. These physical and chemical analyses have been carried out at the laboratory of the Directorate General for Water. They consisted of applying the appropriate techniques for each parameter to be analyzed. Thus, biological, physical, and chemical elements in water samples are measured. The findings are compared with the standards in force in Benin. The vulnerability matrix is based on households' perceptions and the extent of each contamination risk. The centered and reduced anomalies are calculated using the statistical formula:

$$\lambda = \frac{X - \bar{\mathbf{X}}}{\boldsymbol{\sigma}} \qquad (5)$$

where x the average annual rainfall for the year i; $\bar{X}$ and σ respectively represent the mean and standard deviation of the series under study.

3. Results

3.1. Assessment of Hygiene and Sanitation Conditions in Households in the Municipality of Nuatitingo

This section covers methods of managing household waste, wastewater, excreta, and drinking water availability.

3.1.1. Household Waste Management Methods in the Municipality of Natitingou

Two main methods are used for household waste management: traditional and modern methods. Modern methods of solid household waste management involve pre-collection of household waste. These techniques are mainly managed by non-governmental organizations (NGOs) in collaboration with the town hall and the environmental affairs department. These are the NGOs VEA and CNPE. They cover all neighborhoods in the districts of Natitingou 1, Natitingou 2, and Natitingou 3, with only 280 subscribers. The shortage of effective waste collection and treatment systems impacts public health, ecosystems, and quality of life. Traditional methods in Natitingou involve dumping waste in open areas or illegal dumps outside residential areas, and sometimes using individual pits for organic waste. The unsupervised disposal of household waste in open areas and in the rivers that run through the town is a significant environmental pollution issue, increasing health risks, particularly waterborne and infectious diseases, in a context of climate change that further weakens sanitation systems and increases the vulnerability of communities. In fact, 74% of respondents dispose of household waste in the open air, 11% subscribe to pre-collection services, 10% burn their waste, and 5% bury solid household waste (Figure 2). Thus, people are more likely to dispose of household waste in the open air (Photo 1). Waste tends to accumulate due to the lack of effective collection, forming piles of garbage that have turned into unsanitary areas, attracting pests and spreading disease (Figure 3). All districts are full of illegal dumps. The latter are most prevalent in the districts of Kotapounga, Perma, and Natitingou 3. As a result, waste management in the municipality of Natitingou is a real challenge, often characterized by uncontrolled dumping and inadequate collection. This favors the resurgence of waterborne and infectious diseases in an environment already weakened by the effects of climate change.

3.1.2. Wastewater Disposal System in the Municipality of Natitingou

Domestic wastewater management in the municipality of Natitingou is characterized by multitude practices, often informal. There is no widespread collective sanitation system, mainly beyond the city center. Indeed, 63% of the respondents discharge domestic wastewater into the environment and rivers, 13% dispose of it in the yard, 10% use septic tanks or cesspools, 7% use open gutters, 4% use closed gutters, and 3% use soakaways (Figure 4). Poor management of domestic wastewater exacerbates pollution. Given the lack of sewerage networks, wastewater management is mostly individual and often rudimentary. Direct discharge onto the ground or into the environment is the most common practice in rural areas and outlying neighborhoods.

3.1.3. Excreta Management in the Municipality of Natitingou

Excreta management practices vary widely, ranging from open defecation and defecation in rivers to the use of latrines of varying degrees of improvement. Thus, 63% of the people surveyed defecate in the open, 23% use unventilated pit latrines, 7% use ventilated pit latrines, 5% use flush toilets, and 2% use suspended or stilt latrines (Figure 5). Management is therefore almost exclusively autonomous or on-site at the household level. The main methods reported in Natitingou households include open defecation. The rate of open defecation is very high in Kotapounga (65%), Tchoumi-Tchoumi (64%), Kouaba (63%), Kouandata (60%), and Perma (60%). However, Natitingou 1, Natitingou 2, and Natitingou 3 have low rates. So, 40% of districts have really high ODF rates (Figure 6). People also use modern and traditional latrines. Open defecation is common, raising concerns about soil and groundwater contamination.

3.1.4. Drinking Water Availability

The municipality of Natitingou has a mixed drinking water supply system, combining the SONEB (Benin National Water Company) network for urban and semi-urban areas. Its coverage rate is 28.4%. It ranges from 21% to 61% in the municipality of Natitingou. SONEB's coverage rate is very high in urban districts and very low in rural ones (Figure 7). The microbiological quality of water provided by SONEB is generally good initially. However, quality deteriorates between the source and the point of consumption due to poor hygiene practices during transport and storage in households. Water taps are vital in Natitingou’s rural districts, where there is no SONEB

network. Rural districts have 7 water treatment plants with 64 standpipes, of which 2 water treatment plants with 13 standpipes are out of service. In addition, rural districts need 107 water treatment plants to meet population needs (Table 1). The pumped raw water volume is 836 m3 in rural districts of the municipality of Natitingou. The AEV coverage rate is 4.45% and the FPM is 100% coverage rate. The municipality of Natitingou has a wealth of AEVs with standpipes, FPMs, and PEAs. These waterworks serve all districts (Figure 8). There is an uneven distribution of water infrastructure in the municipality of Natitingou. Given the scarcity of drinking water, residents are forced to use unsafe sources such as backwaters and ponds. This heightens the risk of waterborne diseases, especially among children.

3.2. Environmental Pollution and Health Vulnerability

Poor hygiene and sanitation management affects soil and groundwater.

3.2.1. Impacts on Soil

Poor hygiene and sanitation have deep and lasting impacts on soil quality and health, potentially turning soil into a pollutant and source of disease. According to 82% of respondents, the mismanagement of excreta, wastewater, and household waste in the municipality of Natitingou results in environmental contamination. In fact, 44.44% of the area covered by the municipality of Natitingou (Kouaba, Tchoumi-Tchoumi, Kouandata, and Péporiyakou) are moderately unsanitary, 33.33% (Natitingou 1, Natitingou 2, and Natitingou 3) are slightly unsanitary, and 22.23% (Kotopounga and Perma) are highly unsanitary (Figure 9). Thus, the municipality of Natitingou is fairly unsanitary. Unsanitary conditions affect the soil, exacerbating environmental problems. The uncontrolled dumping of household waste and other solid waste on public roads and in nature contributes to the accumulation of non-biodegradable materials (plastics, bags, etc.) that are buried in the soil. This distorts the soil structure, reduces its permeability and water retention capacity, and can prevent plant growth. Decomposing organic waste can produce substances that alter the chemical composition of the soil. Household unsanitary conditions also cause soil pollution (64% of respondents). Waste accumulation and wastewater discharge affect the quality of urban soils, making them unhealthy and restricting their ability to absorb water.

3.2.2. Effects on Groundwater or Surface Water

Pollutants from organic, chemical, or microbial sources in the soil in the municipality of Natitingou seep into the groundwater and contaminate aquifers, which provide drinking water for the local population. Runoff water, laden with waste and pollutants from unsanitary soils, can reach rivers and surface water bodies, causing their degradation and contamination. This affects aquatic life and renders these waters unfit for consumption or other uses. Surface water has been found to have an electrical conductivity of 85.3 µS/cm, total dissolved solids (TDS) of 45 mg/L, and suspended solids of 86 mg/L (Table 2). As a result, surface waters are polluted. Inadequate sanitation leads to the discharge of untreated wastewater and waste into rivers, lakes, and groundwater. This environmental pollution has immediate consequences on public health, as it contaminates drinking water sources and food. In addition, excreta and solid waste contaminate groundwater, posing a major risk. This directly affects people's health, as they depend on drinking water from these sources.

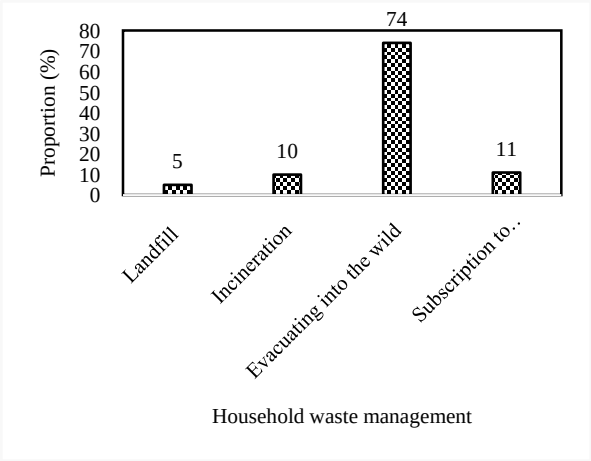
3.2.3. Climate Change Effects on Water Resources and Sanitation Infrastructure in the Municipality of Natitingou

The municipality of Natitingou is bearing the brunt of climate change, which is reflected mainly in variable and irregular rainfall patterns and excessive heat. These climate changes impact water resources. The indices are between -1.53 and 2.04. The period is abundant, with 63% of years being dry and 37% being wet (Figure 10). This alternation between dry and rainy years causes flood risks. The spatial approach made it possible to assess the vulnerability of the research area to flood risks. In fact, 45% of the area covered by the municipality of Natitingou is at low risk, 24% is at medium risk, 21% is at high risk of flooding, and 10% is at very low risk of flooding (Figure 11). The municipality of Natitingou is therefore exposed to flood risks. Flooding in Natitingou, whether caused by heavy rainfall or river overflow, has a severe impact on hygiene and sanitation, creating a vicious cycle that threatens public health and people's well-being. Frequent flooding can overwhelm sanitation systems (latrines, septic tanks), spreading pathogens and pollutants into the environment. This increases people's exposure to health risks. Floodwaters carry impurities, waste, feces, and chemicals. They seep into unprotected wells and poorly constructed or damaged boreholes, and can even pollute drinking water distribution networks through breaches or faulty connections. The municipality of Natitingou is severely affected by excessive heat, a growing and increasingly intense phenomenon. This has significant impacts on daily life, mainly in terms of hygiene and sanitation. The municipality of Natitingou is distinguished by relatively warm minimum and maximum temperatures throughout the year. Temperature indices have been used to identify extremely hot and extremely cool years. Indeed, minimum temperature indices are between -1.10 and 1.43 throughout the study series (1991-2024). Maximum temperature indices increase dramatically from 1991 to 2024 (Figure 12). Also, 59% of study years are warm, with more than half of these occurring in the last three decades, compared to 41% cool years, mainly concentrated in the first two decades of the study period. Global warming caused by greenhouse gas emissions leads to a general temperature rise and more frequent, intense, and longer heat waves. High temperatures naturally increase the need for water for drinking, personal hygiene (frequent showers), and domestic activities. This adds additional strain to water supply systems. Heat waves are often coupled with droughts or declining groundwater levels and the drying up of surface water bodies (backwaters, traditional wells). This diminishes water availability, making access more

difficult and costly. In hot weather, populations may turn to unsafe water sources (unprotected wells, backwaters) that dry up or rapidly deteriorate in quality due to pollutant concentration when improved water sources are too far away. Microbial contamination of water increases with heat. Heat favors certain disease-carrying insects (flies, mosquitoes) attracted to waste and feces improperly managed due to poor sanitation. Climate change exacerbates challenges related to pollution and public health. It affects water availability and quality, as well as water-borne disease frequency. Climate change, like long droughts or heavy rain, affects both quantity and quality of available water. Droughts deplete reserves, while floods can pollute drinking water sources with sewage and waste, making it more susceptible to disease outbreaks. Most of the region's soils are clayey. Severe droughts cause soil shrinkage, which can crack building foundations and roads and damage underground sanitation systems. The shortage of rain to flush gutters and drains encourages the accumulation of waste and sediment, reducing the infrastructure's drainage capacity and making it even more vulnerable once the rains recur.

3.2.4. Human Health Risks in the Municipality of Natitingou

The 2023 Health Statistics Yearbook shows that severe malaria, acute respiratory infections (ARIs), and diarrhea are among the leading causes of death in health facilities in the municipality of Natitingou. Figure 13 shows that cases of uncomplicated and severe malaria have fluctuated, falling from 35,674 in 2003 to 25,466 in 2024, a drop of 28.61%. The curve's coefficient of determination is -451.77. According to 87% of respondents, the emergence of malaria cases is due to poor sanitation practices, including lack of adequate drainage for rainwater and wastewater, and the waste that builds up, which gets in the way of drainage and makes it easier for standing water to form. These water collections are perfect breeding grounds for malaria-carrying anopheles mosquitoes. Flooding caused by poor storm drainage generates large areas of stagnant water, significantly increasing mosquito breeding and, consequently, malaria cases. Poorly managed waste (used tires, empty cans, discarded containers) can retain rainwater and become small breeding grounds for mosquito larvae. Illnesses can be more frequent and severe in an unsanitary environment. Figure 14 shows that acute lower respiratory infections in the municipality of Natitingou rise from 7,856 in 2003 to 9,156 in 2024, peaking at 11,564 in 2006. The curve's coefficient of determination is -72.804. Unsanitary living conditions are often associated with overcrowding and inadequate ventilation in homes. This promotes swift transmission of pathogens through the air, especially in environments with poor air quality. According to 73% of respondents, expanding vaccination coverage against certain childhood diseases that can be risk factors or complications of ARIs (such as vaccination against pneumococcus or Haemophilus influenzae type b, and measles) helps reduce the severity and incidence of these infections. Poor hand hygiene (not washing or insufficiently washing hands after coughing, sneezing, etc.) is a major means of transmission for ARI viruses and bacteria. Drinking water contaminated with fecal matter (due to a lack of latrines, open defecation, flooding, or contamination of water sources) is the main cause of diarrheal diseases. In addition, cases of diarrhea fell from 3,285 in 2003 to 2,745 in 2024, with a peak of 3,467 in 2015 in the municipality of Natitingou, representing a decrease of 16.43% (Figure 15). Waterborne diseases are directly linked to the management of excreta in Natitingou households. Soil and surface water pollution and the rapid spread of diarrhea cases have been observed. Diarrheal diseases are particularly sensitive to water, sanitation, and hygiene (WASH) interventions.



***Source**: fieldsurvey, april 2025*

Figure 2. Household waste management system in the municipality of Natitingou

***Shooting**: Sanga Pema, april 2025*

Photo 1. Part-view of garbage piles in Boriyouré and Perma

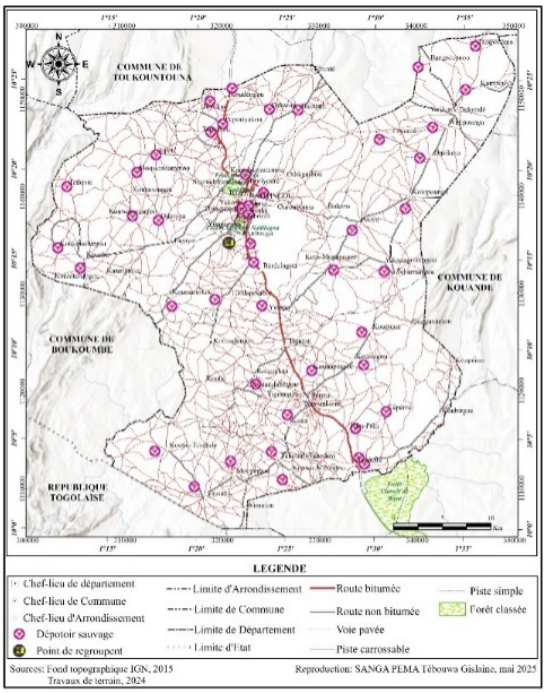
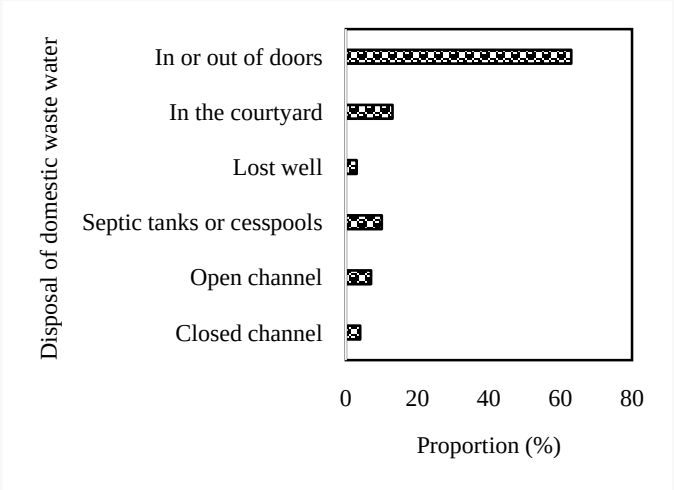
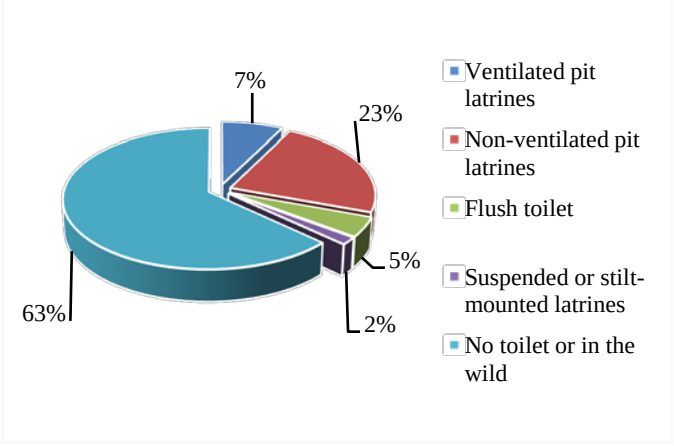


Figure 3. Spatial distribution of litter dumps in the municipality of Natitingou



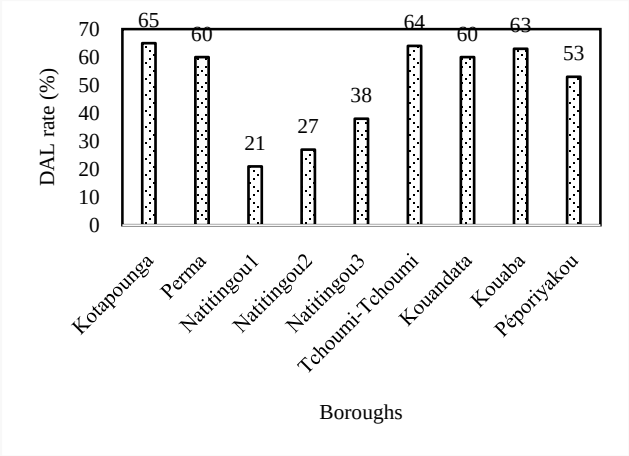
***Source**: fieldsurvey, april 2025*

Figure 4. Wastewater management in the municipality of Natitingou



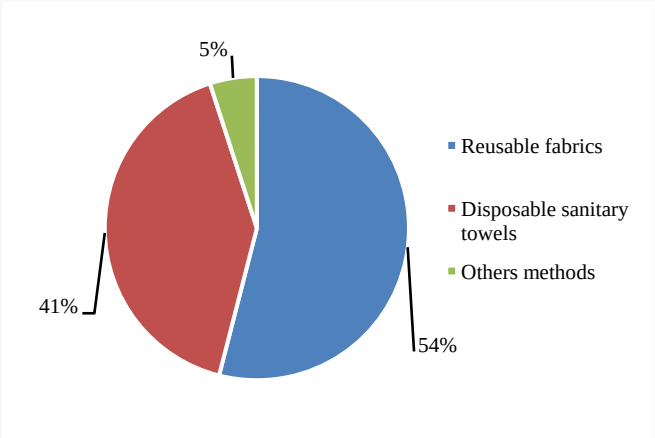
***Source**: field survey, april 2025*

Figure 5. Excreta management in the commune of Natitingou



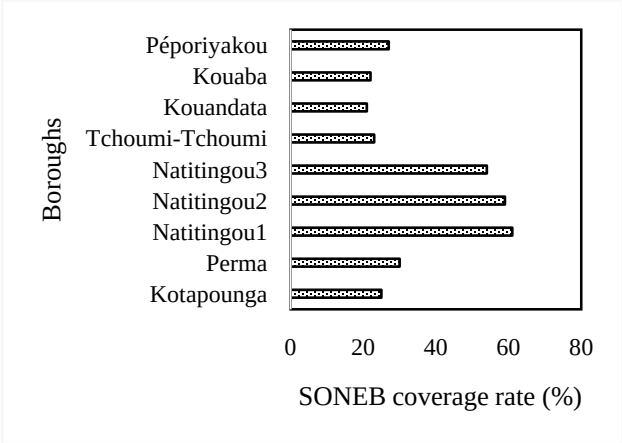
Source: *field survey, april 2025*

Figure 6. DAL rate by district in the municipality of Natitingou



Source: fieldsurvey, april 2025

Figure 7. Menstrual management system in the municipality of Natitingou



Source*: field survey, april 2025*

Figure 8. SONEB water coverage rate in the municipality of Natitingou

Table 1. Number of standpipes in rural areas in the municipality of Natitingou

	Populations	Total number of AEVs with BF	Number of AEVs with faulty BF	Population density ratio per AEV	Standard	AEV requirement
Rural districts	50559	Seven AEVs with 64 BF	Two AEVs with 13 BF	10112	one AEV for 400-500 inhabitants	107

Source*: Natitingou Town Hall, 2025 and field survey, april 2025*

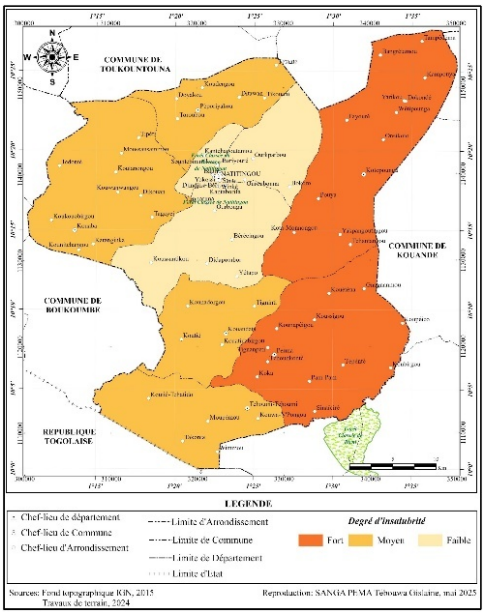
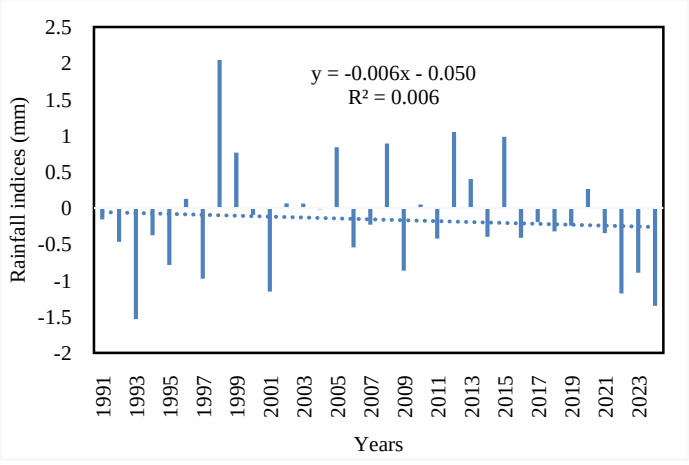


Figure 9. Unsanitary standards in the municipality of Natitingou

Table 2. Physicochemical components of samples taken from surface waters in the municipality of Natitingou

Settings		Sampling	Standard
		Surface water	
Temperature (°C)	-	27,2	>1 mil recp
Hydrogen potential (pH)	-	7,28	6-9
Electrical Conductivity (EC)	µS/cm	85,3	
Total Dissolved Solids (TDS)	mg/L	45	
Salinity	‰	<0,1	
Suspended matter (MES)	mg/L	86	35
Total phosphors (P-PO_4^{3-})	mg/L	7,74	
Total Kjeldahl Nitrogen (NTK)	mg/L	8,5	15
Ammonium (N-NH_3)	mg/L	0,19	
Chemical O2 Demand (DCO)	mg/L	136,93	125
Biochemical O2 demand (DBO^5_{20})	mg/L	138	125
Dry matter (MS)	%	-	
Total Kjeldahl Nitrogen (NTK)	mg/kg	-	15
Ammonium (N-NH_3)	mg/kg	-	
Phosphores totaux (P-PO_4^{3-})	mg/kg	-	2

Source: *Field survey, april 2025*



Source*: Data processing by Meteo-Benin, april 2025*

Figure 10. Rainfall indices between 1991 and 2024 in the municipality of Natitingou

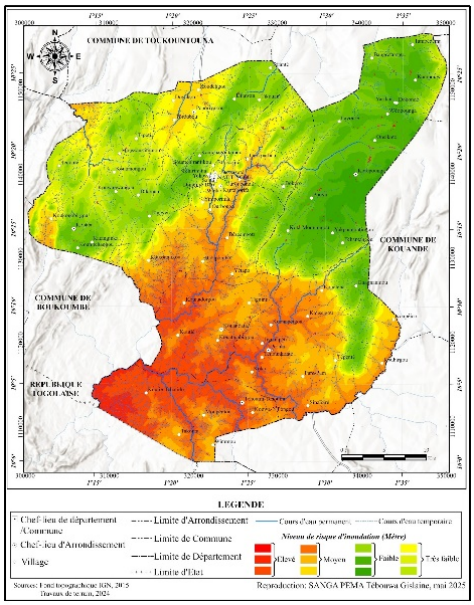
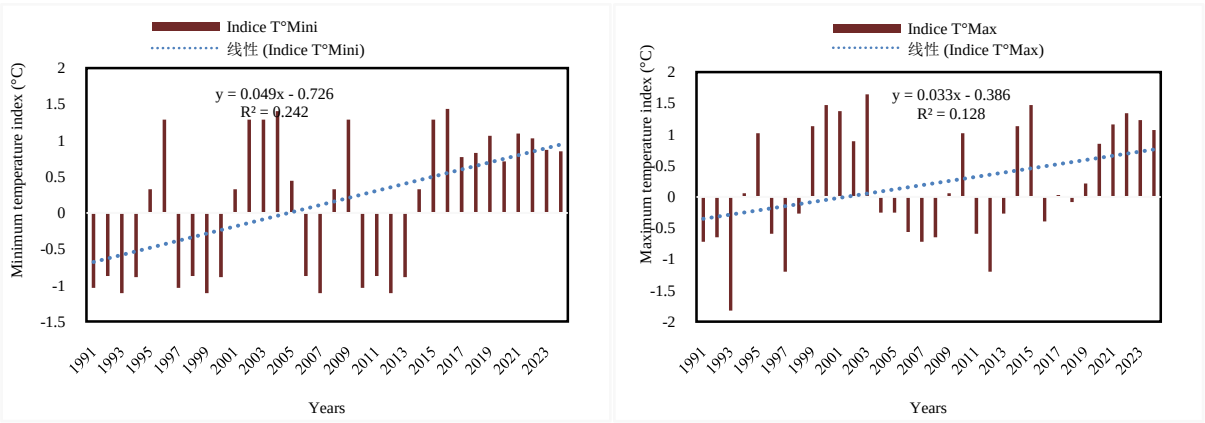
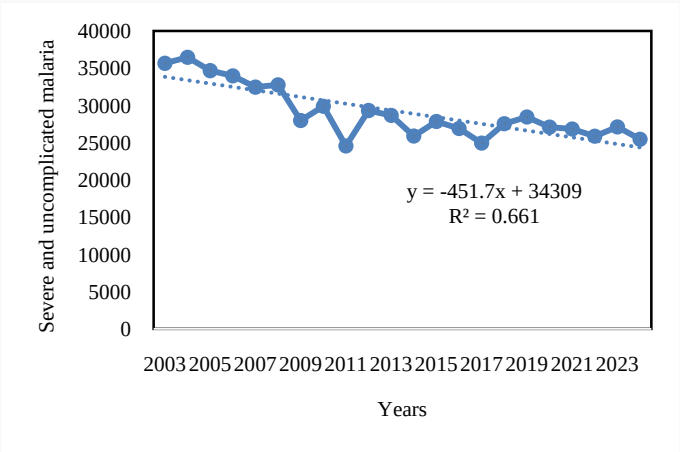


Figure 11. Distribution of the research sector's vulnerability to flood risks



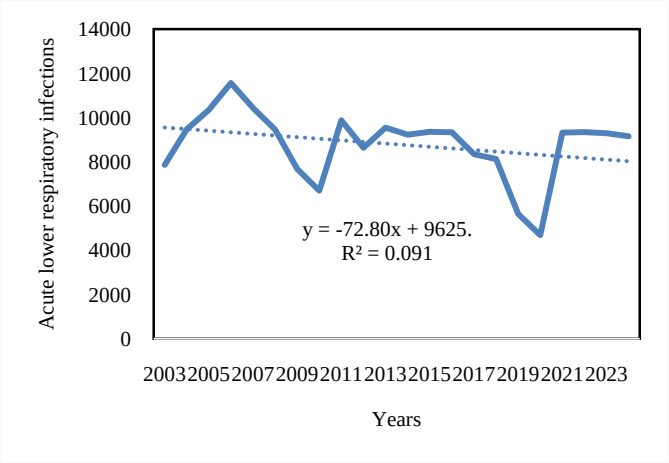
Source: *Data processing by Meteo-Benin, april 2025*

Figure 12. Thermal index trends in the municipality of Natitingou from 1991 to 2024



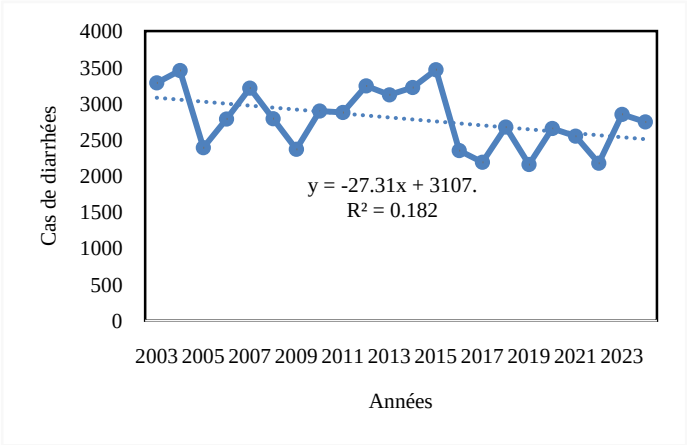
Source: *MS Data Processing, april 2025*

Figure 13. Trends in uncomplicated and severe malaria in the municipality of Natitingou from 2003 to 2024



Source: *MS Data Processing, april 2025*

Figure 14. Progression of acute lower respiratory infections in the municipality of Natitingou from 2003 to 2024



Source: *MS Data Processing, april 2025*

Figure 15. Progression of diarrhea in the municipality of Natitingou from 2003 to 2024

3. Discussion

Findings show that traditional methods in the municipality of Natitingou involve dumping waste in open areas or illegal dumpsites outside residential areas, and sometimes individual pits for organic waste. In fact, 74% of respondents dispose of household waste in the open, 11% subscribe to pre-collection services, 10% burn their waste, and 5% bury solid household waste. These results concur with those of [15], who found that urban concentration leads to the production of large quantities of waste of all kinds. However, their disposal generates significant challenges. It should be noted that factors related to population growth contribute to unsanitary conditions. This study relates population growth to waste production, showing that population growth leads to the production of significant amounts of waste. In the same vein, [16] demonstrates that environmental problems worsen with great concern in underdeveloped countries, particularly in Benin, as populations increase. Thus, he shows that rapid population growth is a huge obstacle to environmental protection. For [17], awareness of sustainable environmental management has been growing since the publication of the Brundtland Report (1987) and reached its peak at the Earth Summit (June 1992), where Africa, alongside other nations, embrace “sustainable development” principles. This has led to the development of various environmental impact studies and assessments. Furthermore, [18] has shown that a shortage of specific equipment can lead to school dropout and failure. For [19], the lack of decent sanitation infrastructure not only favors the emergence and spread of contagious and widespread diseases (cholera, malaria, etc.), but also makes learning conditions extremely difficult for students.

4. Conclusion

It results from this study that hygiene and sanitation practices are strongly influenced by a combination of physical and human factors in the municipality of Natitingou. Household waste management is a major challenge for local populations, with traditional and modern methods used interchangeably. Poor excreta, wastewater, and solid waste management significantly pollutes soil and water resources, jeopardizing public health through waterborne diseases transmission. These practices also damage local ecosystems, reduce biodiversity, and weaken the community’s environmental resilience. In the context of climate change, these failures in hygiene and sanitation exacerbate health and

environmental vulnerabilities. Extreme weather events (heavy rains, prolonged droughts) boost pollution, help spread disease vectors, and mess up soil and water regeneration cycles. Poor hygiene therefore becomes not only a health risk factor, but also a catalyst for ecological imbalances exacerbated by climate change. In light of these findings, it is crucial to strengthen sanitation infrastructure, promote sustainable hygiene practices, and raise awareness among populations about the interdependence between health, environment, and climate. These are key steps to ensure fair and resilient development in the community of Natitingou.

Conflict of Interests

The authors declare that they have no conflict of interest.

References

[1] World Bank, Decentralization Policies and Sanitation Service Management in Africa, 2020, 7.

[2] *Sebo V. E.*, Cassava production vulnerability to climate change and adaptation priorities in Benin-Togo border communities (Mono Valley, West Africa). Doctoral thesis in Geography and Environmental Management, EDP/GENV/FLASH/UAC, *2014*, 337.

[3] Ehou S. O. T., Drinking water and public health in the municipality of Dangbo: Case studies of the districts of Kessounou and Houedomey. Master's thesis in Risk Prevention and Disaster Management. UAC/FLASH/MIRD, 2016, 128.

[4] OMS/UNICEF, Achieving the SDGs for drinking water and sanitation: Mid-term progress assessment, 2017, 31.

[5] ONU, World Economic Situation and Prospects 2016. New York (United States of America), 2015, 74.

[6] Gabert J., Sanitation checklist: challenges and current situation, 2018, 23.

[7] Savadogo K., Best practices research/experience sharing on promoting household sanitation. Final Report, 2016, 34.

[8] Houansou K. P. D., Wastewater and excreta management in Akassato district (Abomey-Calavi municipality). Bachelor's thesis in geography, 2023, 42.

[9] WHO, Women, water, and sanitation, 2015, 35.

[10] Salou Bachirou Z., Tossoulegue S., V., Bedie D., Degnonvi H., Boni G., Fandohan Y. I. A., Amoukpo I. L. H., Toffa D., Johnson R. C., Effects of hygiene and sanitation promotion interventions on knowledge, attitudes, and practices (KAP) regarding water, hygiene, and sanitation among members of groups in the Sedje-Denou district in the municipality of Zè in southern Benin. Article, Medicine and Public Health Scientific journal _ The CBRST Notebooks Medicine and Public Health No. 15, Special edition, 2019, 184-200.

[11] Sossou A. N., Hygiene and sanitation in primary and secondary schools in the municipality of Bohicon, Benin. Master's thesis. University of Abomey-Calavi. 2018, 68.

[12] Bamkole E., Hygiene and sanitation in public secondary schools in the Azowlisse district (Adjohoun municipality). Bachelor's thesis, DGAT/FASHS/UAC, 2021, 67.

[13] INSAE, General Population and Housing Census, Fourth Phase, Provisional Results, DED, Cotonou, 2013, 28.

[14] Bocovo A., Bocovo F. and Azonhe T. H. S., Unhealthy conditions in secondary schools in Abomey (central Benin). Plurasex World collection, 2023, 23-40.

[15] OMS/UNICEF, Drinking water and sanitation progress: special focus on sanitation, 2008, 58.

[16] Azonhe T., Hygiene and sanitation in the municipalities of Djègbadji and Houakpé-Daho in Ouidah, southern Benin. Master's thesis in Geography, DGAT/FLASH/UAC, 2000, 88.

[17] WaterAid., State of the World's Toilets 2015, 2015, 54.

[18] Kassin A., Hygiene and sanitation issues in schools: case study of public elementary schools in the municipality of Bantè, 2012, 84.

[19] MS, Ministry of Health Statistical Yearbook 2023, 2023, 243.