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RESEARCH ARTICLE

DOMESTIC WASTEWATER MANAGEMENT AND ENVIRONMENTAL IMPACTS IN THE ZANZAN AND LYCÉE NEIGHBOURHOODS OF BONDOUKOU, CÔTE D'IVOIRE

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Abstract

Rapid and often unplanned urbanisation makes domestic wastewater management a major environmental and publichealth concern in secondary towns in Côte d'Ivoire. This study examined household wastewater practices and residents' perceptions of associated environm ental and health concerns in the Zanzan and Lycée neighbourhoods of Bondoukou. It combined a household questionnaire (200 households; 100 in each neighbourhood), interviews with local institutional stakeholders, field observations, and GIS-based mapping. The survey found that 33% of households in Zanzan and 7% in Lycée reported having a drainage system, while discharge into streets was reported by 57% and 53%, respectively. Stagnant water, perceived pollution, and unpleasant odours were reported; 43% of respondents in Lycée reported water-related diseases, whereas none in Zanzan reported such diseases. These are self reported perceptions and are not clinical evidence that w astewater caused disease.In both neighbourhoods, 77% of respondents reported no sanitation - awareness activity. Infrastructure was the leading improvement priority (62% in Zanzan and 65% in Lycée). The study provides a local diagnostic to support sanitation planning, while its cross-sectional, self-reported data and limited spatial analysis mean that environmental contamination and disease causality cannot be established.

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Recommendations therefore focus on verified site assessments, fit-for-purpose sanitation options, safe faecal-sludge management, community engagement and the use of geospatial data to prioritise further investigation.

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Introduction:-

Inadequate sanitation has substantial economic, environmental and public health consequences. The World Bank's Water and Sanitation Program (2012) documented significant economic losses associated with poor sanitation in several African countries. In Côte d'Ivoire, insufficient wastewater collection and drainage infrastructure remains a challenge for sustainable water-resource management and urban development. Bondoukou, in the north-eastern part of the country near the Ghanaian border, has grown through its administrative, commercial and university functions. The manuscript cites the 2021 General Population and Housing Census (RGPH, 2021) for a population of approximately 102,590 in 2021; the additional estimate of 122,309 for 2025 requires a traceable official source before it can be treated as an observed statistic. Population growth and the expansion of peripheral neighbourhoods can increase pressure on sanitation services. In Zanzan and Lycée, residents' wastewater disposal practices occur in a context of limited drainage infrastructure and uneven household capacity to invest in improved on-site sanitation. During the rainy season, wastewater in streets and drains may be mobilised into nearby low-lying areas; however, this study did not measure pollutant concentrations in water or soil.

The research question is: what domestic wastewater management practices are reported in Zanzan and Lycée, what environmental nuisances and health concerns do residents report, and how can the findings inform local sanitation planning? The study addresses a local evidence gap by bringing together household responses, institutional interviews, direct observations and a GIS location framework in two neighbourhoods of a secondary Ivorian city. Its contribution is diagnostic rather than causal: the available spatial output locates the study area, while the survey describes neighbourhood-level practices and priorities; it does not establish a validated spatial risk model. The overall objective was to analyse domestic wastewater management and its reported environmental and health implications. Specifically, the study sought to identify disposal practices, document reported nuisances and health concerns, and propose context-sensitive planning measures.

Materials and Methods:-

Description of the study area

Bondoukou is located approximately 425 kilometres from Abidjan. As the capital of the Gontougo Region, the town covers an area of 28.73 km². The Zanzan and Lycée neighbourhoods investigated in this study lie between northings 886,000 and 892,000 m and westings 517,000 and 526,500 m. They are located in the central part of the urban area, to the west of Bondoukou (Figure 1).

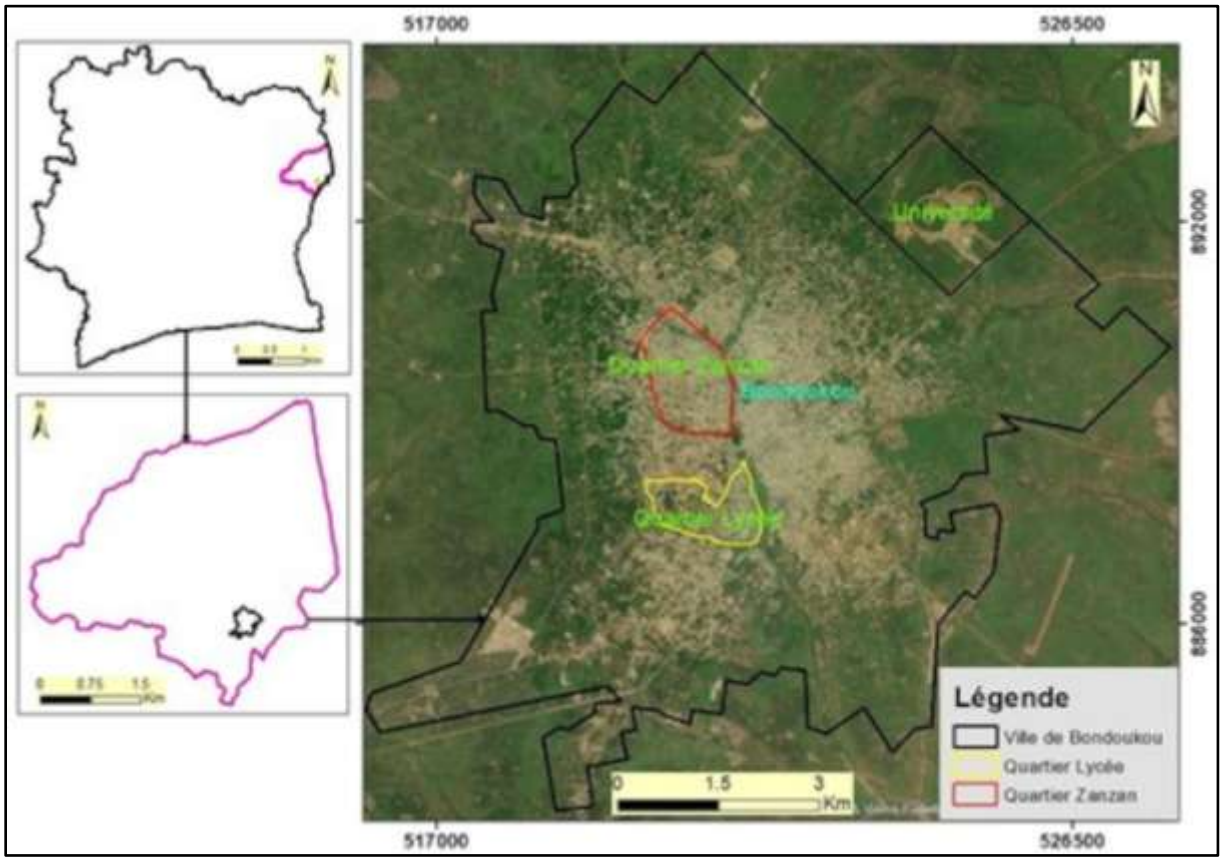


Figure 1: Location of the Zanzan and Lycée neighbourhoods of Bondoukou
Source: Konin, 2026

Materials:-

The materials comprised KoboToolbox/KoboCollect for digital questionnaire administration and georeferenced fielddata collection; QGIS and Google Earth Pro for spatial visualisation and map production; and a digital camera for documenting visible sanitation conditions. The study also used a digital elevation model (DEM) for the location map, an interview guide for institutional stakeholders, and a structured household questionnaire. The available manuscript records do not specify the DEM source, spatial resolution, coordinate reference system or map scale; these metadata should be added from the original GIS project before final submission.

Methods:-

The study used a descriptive, cross-sectional design and comprised a literature review and field investigation. The literature review consulted scientific publications and reports from organisations including WHO, UN-Habitat, the World Bank and UNICEF, mainly through Google Scholar and HAL. It informed the study indicators and placed the local case in the wider context of sanitation in sub-Saharan Africa. The field component combined household questionnaires, institutional interviews and direct observation of visible wastewater-disposal conditions.

A total of 200 households were surveyed, with a fixed allocation of 100 households in each neighbourhood. The source manuscript does not document a sampling frame, the method used to select individual households, eligibility criteria, the number of households approached or the response rate. Consequently, the sample must be interpreted as an exploratory neighbourhood survey rather than a statistically representative sample of all households in Bondoukou. These details should be checked against the original field records and reported if available. An interview guide was administered to representatives of the Regional Directorate for the Environment and the Municipal Technical Department. Field observations documented visible discharge points and sanitation conditions; photographs were taken. The questionnaire covered household characteristics, water sources, drainage and wastewater-disposal practices, reported nuisances and health concerns, awareness activities and improvement priorities.Data processing and analysis. Questionnaire responses were summarised using descriptive counts and

percentages, separately for each neighbourhood. No inferential statistical tests are reported because the manuscript provides no respondent-level dataset or documented test procedure from which test statistics and p-values could be reproduced. Percentages should therefore be interpreted descriptively, not as evidence of statistically significant differences between neighbourhoods. Before submission, the authors should verify all percentages against the original KoboToolbox export and ensure that the denominator for each item, including multiple-response questions and missing responses, is stated consistently.

GIS procedure and scope. QGIS and Google Earth Pro were used to prepare the location map and visualise the study area and field observations. On the information currently documented, the GIS component supports geographic contextualisation but does not include a quantified overlay of discharge points, elevation, population exposure or environmental sensitivity. The manuscript therefore does not claim that high-risk zones have been modelled or validated. To strengthen the spatial contribution, the original GIS project should be used, where available, to map georeferenced discharge observations and relate them to drainage pathways and low-lying areas; any such analysis must be reported only if it was actually performed and its data and parameters can be documented.

Ethics and data quality. Participation in the household survey should have been voluntary, with the study purpose explained and informed consent obtained before questions were asked. The manuscript's source materials do not provide a formal ethics approval number or a written consent protocol; the authors should confirm the actual procedures used and report them accurately rather than imply approval that was not obtained. Household responses should be reported in aggregate, and identifying details should not be disclosed. Field observations describe visible conditions and respondents' perceptions; no laboratory testing of water or soil and no review of clinical records were conducted.

Results:-

Institutional interviews

Domestic wastewater management

The institutional interviews identified the Regional Directorate for the Environment and the Municipal Technical Department of Bondoukou as stakeholders involved in domestic wastewater management. Interviewees described inadequate sanitation infrastructure, including limited or insufficient open drainage channels. They associated these constraints with urban growth and limited investment. Field observations and interview accounts indicate concerns about stagnant water, visible discharge and degraded living conditions; however, this study did not directly measure soil or water contamination, vector density or flood risk.

Reported health impacts

Institutional stakeholders mentioned malaria, tuberculosis, unpleasant odours and, in some cases, deaths associated with pits. These statements are reported as stakeholder accounts only. No clinical records, diagnostic confirmations or epidemiological surveillance data were collected, and the study cannot establish that the reported illnesses or deaths were caused by domestic wastewater.

Measures to prevent and reduce health impacts

Stakeholders reported hygiene, sanitation and awareness activities in the two neighbourhoods, including public-awareness sessions on hygiene and sanitation, waste management and neighbourhood cleaning. These activities were described by interviewees; their frequency, reach and effectiveness were not independently evaluated in this study.

Household survey:-

Socio-demographic profile

The survey respondents comprised 63% women and 37% men in Zanzan, and 57% women and 43% men in Lycée. Household size is shown in Figure 2. In Lycée, five-person households were the most common, accounting for 27%, while two-person households accounted for 20%. In Zanzan, households comprising three or six people were most common, each representing 20%.Modern housing was reported by 77% of respondents in Zanzan and 73% in Lycée. Semi-modern housing accounted for 17% in Zanzan and 27% in Lycée; traditional housing was reported by 7% in Zanzan and none in Lycée. The Zanzan percentages sum to 101%, which may reflect independent rounding or a coding/recording inconsistency. The underlying records should be checked; the values are retained here without silently reallocating percentage points.

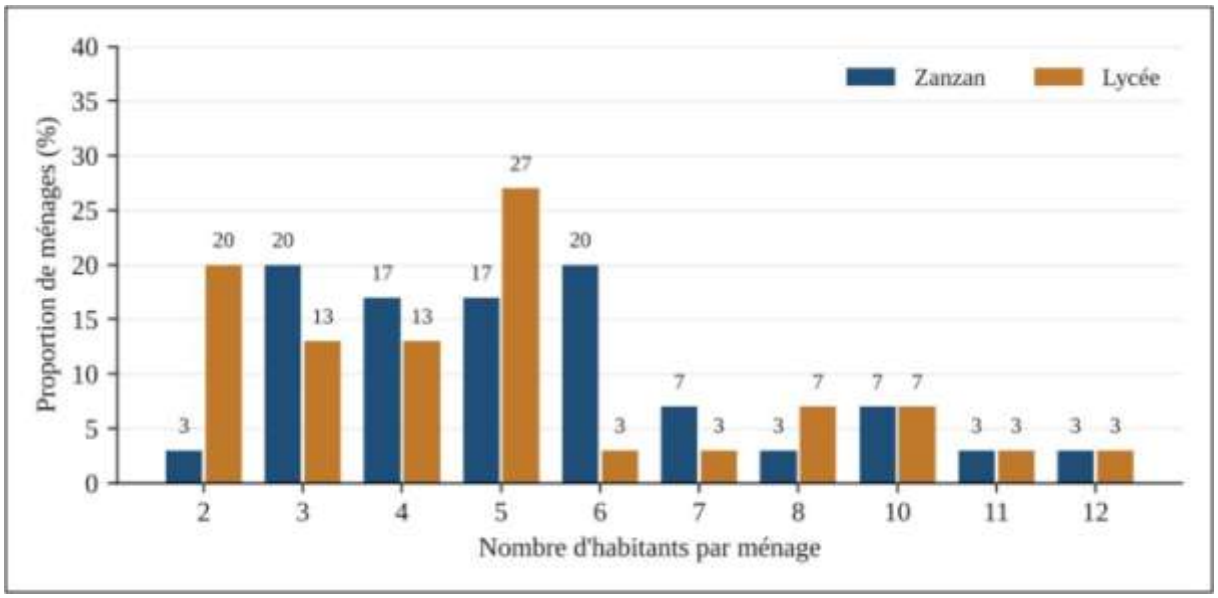


Figure 2: Household size (number of occupants) in the Zanzan and Lycée neighbourhoods
Source: Field survey, 2026

Sources of drinking water

The Zanzan and Lycée neighbourhoods have access to tap water, boreholes and wells (Figure 3). Tap water is the main source used in both neighbourhoods (93%). Well water is used by 13% of households in Zanzan, compared with 30% in Lycée. Borehole water is used by 13% of households in Zanzan and 17% in Lycée.

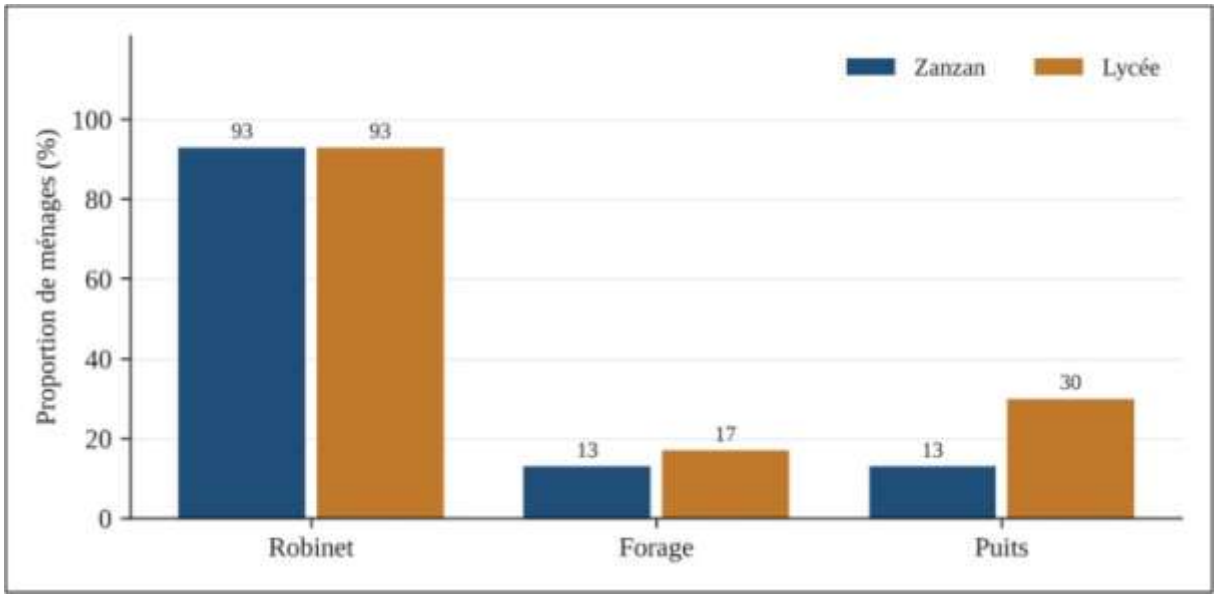


Figure 3: Main water source in the Zanzan and Lycée neighbourhoods
Source: Field survey, 2026

Stormwater drainage methods

In Zanzan and Lycée, 33% and 7% of households, respectively, reported having a drainage system (Figure 4). Among households reporting a system, 50% in Zanzan and 100% in Lycée described it as functional. These figures refer to household reports and should not be interpreted as an engineering inspection of network performance.

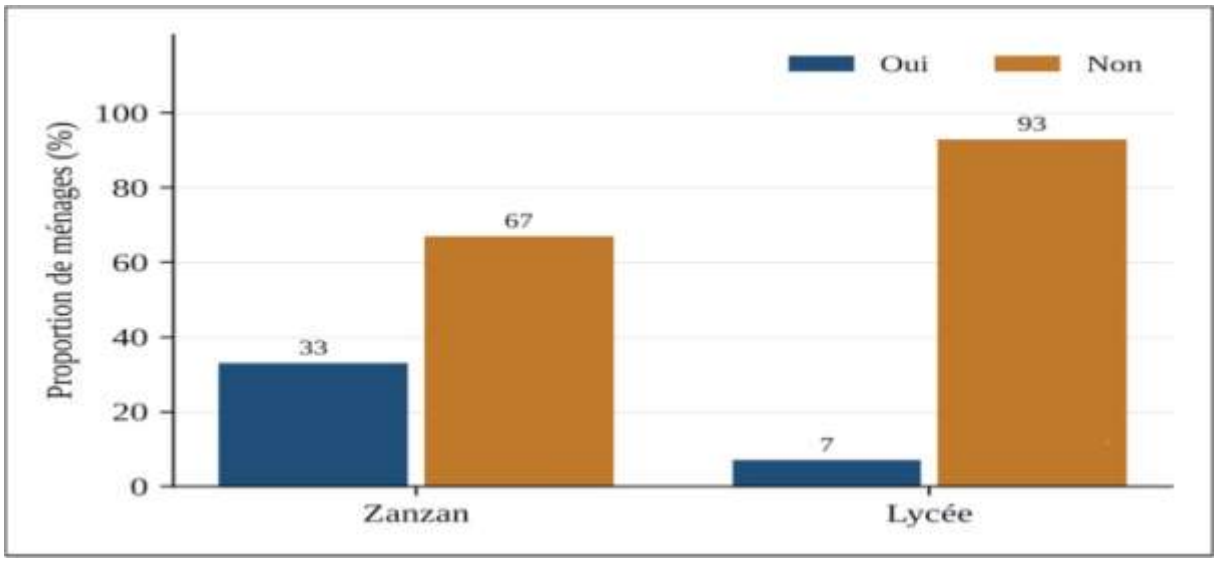


Figure 4: Households with a water drainage system

Source: Field survey, 2026

Domestic wastewater management practices

The most frequently reported discharge location for domestic wastewater is the street, accounting for 57% in Zanzan and 53% in Lycée (Figure 5). Septic tanks are used by 13% of households in Zanzan and 27% in Lycée. Drainage channels are used by 20% in Zanzan and 13% in Lycée.

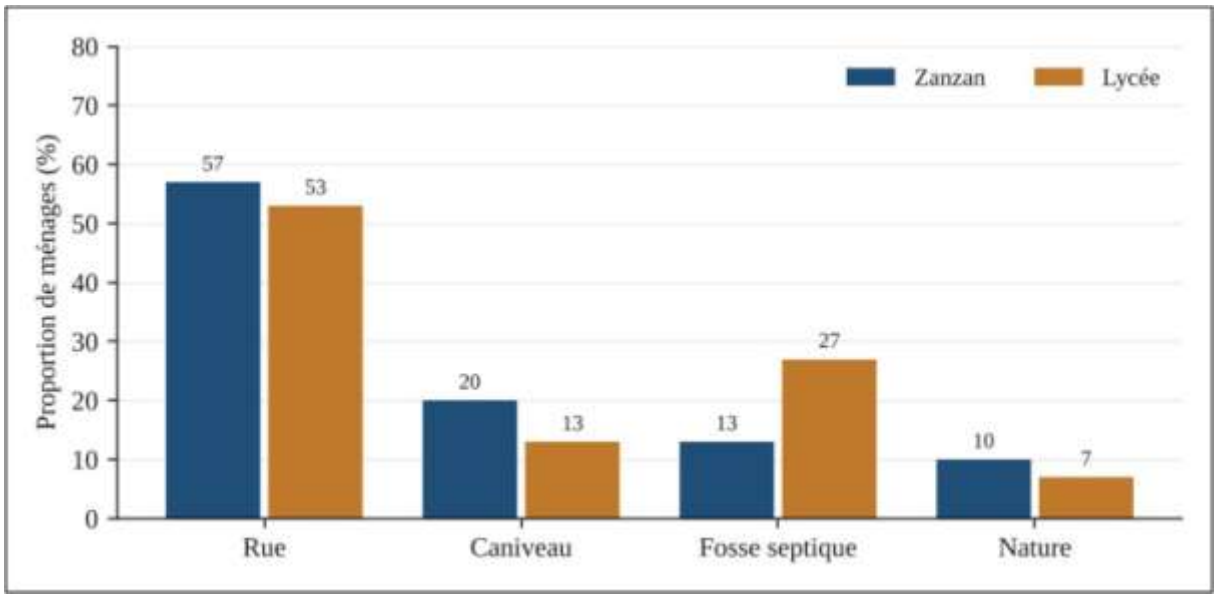


Figure 5: Domestic wastewater discharge locations

Source: Field survey, 2026

Impacts associated with domestic wastewater discharge

In Zanzan, 20% of respondents reported problems associated with domestic wastewater discharge, compared with 40% in Lycée (Figure 6). Reported problems included stagnant water, perceived water pollution and unpleasant odours. These are reported experiences or perceptions; no laboratory analyses were undertaken to confirm contamination.No respondents in Zanzan reported water-related diseases, whereas 43% of respondents in Lycée reported the presence of water-related diseases, including malaria. These responses were not verified against clinical records and cannot establish a causal relationship with wastewater exposure. In both neighbourhoods, 77% of respondents stated that they had not received sanitation-awareness information.

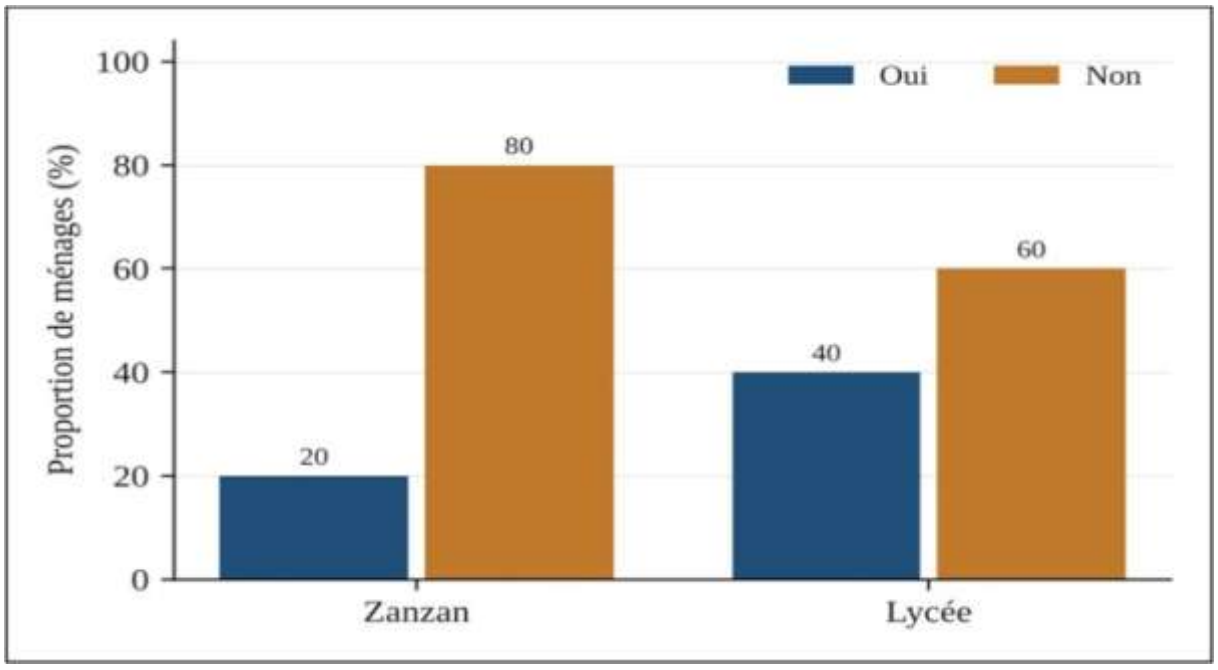


Figure 6: Households reporting problems associated with domestic wastewater discharge
Source: Field survey, 2026

Priority areas for improving the sanitation system
In both Zanzan and Lycée, 87% of respondents wanted the sanitation system to be improved. Infrastructure was the leading priority, cited by 62% of respondents in Zanzan and 65% in Lycée (Figure 7). In Zanzan, awareness-raising and waste management were each cited by 19%; in Lycée, awareness-raising was cited by 23% and waste management by 12%.

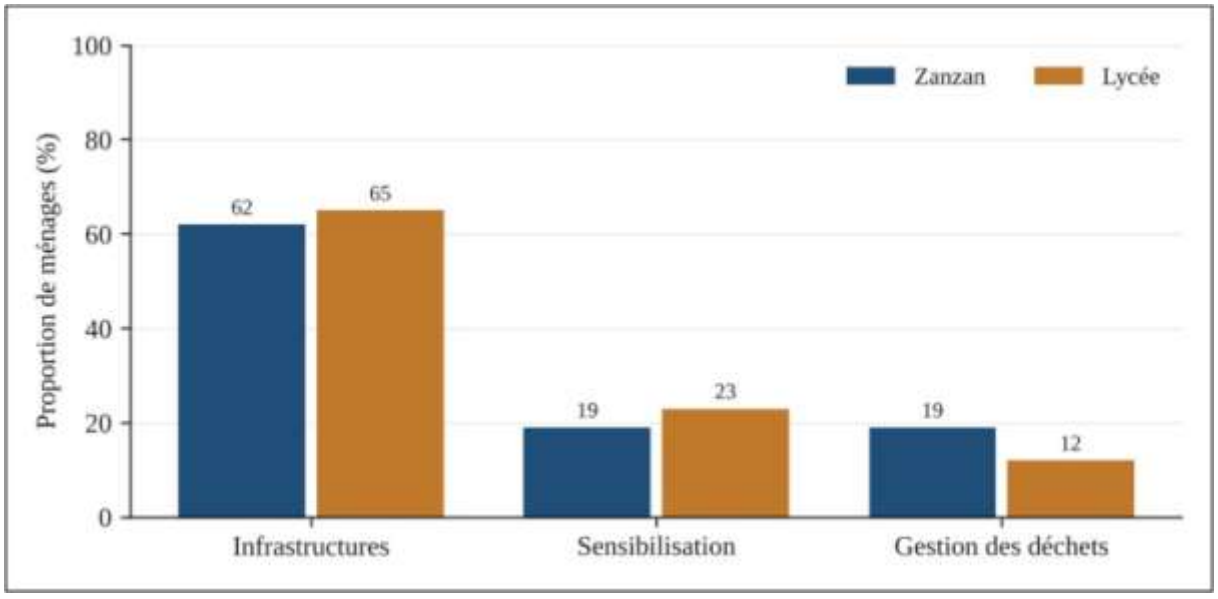


Figure 7: Priority components for improving the sanitation system
Source: Field survey, 2026

Main challenges
The challenges associated with domestic wastewater management fall into three interdependent categories**:**
Structural: inadequate infrastructure, particularly in peri-urban areas where access to a centralised sewerage network remains limited (identified as a priority by 62–65% of residents).

Economic: insufficient financial resources to build, maintain and adopt technical solutions.
Behavioural: household practices, including uncontrolled discharge and inadequate maintenance, which worsen the situation.

The findings support assessing decentralised sanitation options alongside longer-term network planning, rather than assuming that one option is universally preferable. Septic tanks and soakaway pits should be recommended only after site-specific checks of soil permeability, groundwater depth, flood exposure, required setbacks from wells and buildings, and applicable national standards. Safe operation also requires scheduled desludging, access for emptying vehicles, and a documented route to an authorisedfaecal-sludge treatment or disposal facility. Where these conditions cannot be met, alternative contained systems or a planned sewerage solution should be considered with the municipal authorities.

Discussion:-

The findings indicate important sanitation-service gaps in the Zanzan and Lycée neighbourhoods. Reported drainage-system coverage was low (33% in Zanzan and 7% in Lycée), and discharge into streets was common (57% and 53%, respectively). Respondents also described stagnant water, perceived pollution and unpleasant odours. These findings are consistent with broader concerns reported in studies of urban sanitation in West Africa; however, differences in sampling design, indicators and settings mean that numerical results should not be treated as directly comparable.

Inadequate infrastructure and discharge practices

Household responses and institutional interviews point to limited drainage facilities and frequent street discharge. Such conditions can create nuisance and may allow wastewater to contact soil, surface water or people; nevertheless, the present study did not test soil or groundwater and cannot confirm contamination at the study sites. Dongo et al. (2008, 2010) documented sanitation challenges in disadvantaged neighbourhoods of Yopougon, Abidjan. The comparison is contextual: the studies share concerns about inadequate infrastructure, but the available data do not establish identical exposure levels or health outcomes.

At regional level, the WHO/UNICEF Joint Monitoring Programme (2023) reports that only 31% of Africa's population had access to safely managed sanitation in 2022. Achieving universal coverage by 2030 would require a considerable acceleration in progress (a 23-fold increase for safely managed sanitation). In this context, the widespread discharge of wastewater into the open environment or stormwater networks observed in Bondoukou reflects structural failures described by Ouattara et al. (2023) in Abidjan's sanitation systems and more broadly in sub-Saharan Africa, including illegal dumping of solid waste into drains, unauthorised connections, ageing infrastructure and inappropriate household practices.

Health impacts and risk perception

Malaria was the health concern most frequently mentioned in institutional accounts, and 43% of respondents in Lycée reported water-related diseases, including malaria. This is a self-reported finding, not a clinical diagnosis or proof of causation. Stagnant water can provide habitats for mosquito larvae under suitable ecological conditions, and research has documented the relevance of drains to vector habitats in some urban settings (Castro et al., 2010; Doumbe-Belisse et al., 2021). However, this study did not identify mosquito species, sample larvae, measure vector density or link individual disease cases to wastewater exposure.

Tuberculosis, unpleasant odours and risks associated with pits were mentioned by institutional stakeholders. Tuberculosis is not classified as a waterborne disease, and its mention should not be interpreted as evidence of a wastewater-related transmission pathway. The absence of reported water-related disease in Zanzan, despite similar reported sanitation constraints, may reflect differences in recall, awareness or reporting, but the available data cannot determine the explanation. Epidemiological conclusions would require clinical or surveillance data and a suitable study design.The finding that 77% of respondents had received no sanitation-awareness information indicates a perceived gap in communication and outreach. Stakeholders reported awareness sessions and neighbourhood cleaning, but the study did not independently measure their coverage or effectiveness. WHO (2018) emphasises that sustainable sanitation improvements require an integrated approach combining safe services, behaviour change and effective management.

Community priorities and structural challenges

Nearly 87% of residents support improvements to the sanitation system. Infrastructure ranks first among their priorities (62–65%), followed by awareness-raising and waste management. This ranking is consistent with the integrated approach promoted by WHO and UNICEF, which recognises that technical solutions alone, without behavioural and institutional support, struggle to deliver lasting results. The main constraints identified (limited financial resources, inadequate infrastructure and household practices) are consistent with structural factors frequently reported in African urban and peri-urban areas (WHO/UNICEF, 2023; Ouattara et al., 2023).

A phased strategy should be based on a technical assessment rather than a blanket preference for decentralised systems. Options may include compliant septic tanks and soakaway pits where hydrogeological conditions and setback requirements permit, alongside improved latrines, scheduled emptying and safe faecal-sludge treatment. The municipality should assess local groundwater depth, soil infiltration, flood-prone locations, service-provider capacity and lifecycle costs before selecting technologies. The study did not itself assess these parameters, so the feasibility of individual technologies remains to be established.

Implications, limitations and prospects

The findings suggest that sanitation priorities and reported nuisances differ between the two neighbourhoods. Lycée had a higher proportion of respondents reporting problems (40% versus 20% in Zanzan), while septic tanks were more frequently reported in Lycée (27% versus 13%). These descriptive contrasts may help frame follow-up investigations but should not be interpreted as statistically significant differences because inferential tests were not conducted.Several limitations affect interpretation: the household data are self-reported and may be affected by recall and social-desirability bias; the manuscript does not document a probability-based sampling frame or response rate; and the available analysis is descriptive. No microbiological or physicochemical tests of water or soil, vector sampling, clinical-record verification or longitudinal disease data were collected. The GIS output primarily locates the study area and does not constitute a validated risk map. Future work should document sampling procedures, verify questionnaire data, map observed discharge points, sample environmental media using appropriate protocols, and collaborate with public health services where epidemiological analysis is intended.

Conclusion:-

The study documents substantial reported gaps in domestic wastewater management in the Zanzan and Lycée neighbourhoods of Bondoukou. Although access to piped water was widely reported, drainage-system coverage was limited and discharge into streets was common. Respondents described stagnant water, perceived pollution and unpleasant odours, while some reported water-related diseases. These health reports were not clinically verified, and the study cannot establish that wastewater caused disease or confirm environmental contamination.

The findings support an integrated local response combining infrastructure planning, community engagement and stronger service governance. The study contributes a neighbourhood-level diagnostic based on household reports, institutional interviews and field observations, with GIS used to locate the study area. It does not provide laboratory confirmation or a validated spatial risk model. Its implications for SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities) should therefore be understood as planning priorities for further assessment and action.In the short term, the municipality and community leaders could organise targeted awareness activities on safe wastewater disposal, hygiene and reporting of blocked or unsafe drains. In the medium term, a technical assessment should identify feasible household and shared sanitation options, including groundwater protection, safe emptying and faecal-sludge treatment arrangements. In the longer term, the neighbourhoods should be integrated into municipal sanitation and drainage planning. A local monitoring group involving municipal services, environmental authorities and residents could track complaints, infrastructure maintenance and implementation progress. These recommendations require consultation with the relevant authorities and should be adapted to technical feasibility and available funding.

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