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Research Paper

Problematic Of Sanitation and Population Health in the City Of Bondoukou (North-East of the Cote D'ivoire)

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***ABSTRACT**:*
The inadequacy of sanitation facilities in Bondoukou in the face of accelerated and uncontrolled urban growth is a real concern because of the resulting environmental problems. Despite the combined efforts of the State and the population, the living environment remains degraded, exposing the population to numerous health risks. This study aims to show the relationship between sanitation problems and the pathologies suffered by the inhabitants of Bondoukou. The study was based on documentary research and field surveys. The documentary analysis made it possible to take stock of the research on environmental degradation and its impact on the health of the population. Field observation, a questionnaire survey of 201 heads of households and interviews with Bondoukou authorities provided information on the problem of wastewater and storm water sanitation and the impacts of poor liquid waste management on the health of the population. The results obtained from this study show that the neighborhoods do not have the same levels of degradation. There is a strong correlation between the quality of the household environment and the prevalence of environmental pathologies. The most common pathologies are dermatitis (13.54%), malaria (40.46%), typhoid fever (3.76%), acute respiratory infections (05.64%), diarrhea (29.59%), conjunctivitis (05.46%), bilharzia (0.48%) and other diseases (1.07%).
Keywords: Bondoukou, sanitation, waste management, population health, environment.

RÉSUMÉ
L'insuffisance des ouvrages d'assainissement à Bondoukouface à la croissance urbaine accélérée et non maîtriséeconstitue une véritable préoccupation en raison des problèmes environnementaux qui en découlent. Malgré les efforts conjugués de l'Etat et de la population, le cadre de vie demeure dégradé exposant ainsi les populations à de nombreux risques sanitaires. Cette étude vise à montrer le rapport entre les problèmes d'assainissement et les pathologies dont souffrent les habitants de Bondoukou. L'étude s'est basée sur la recherche documentaire et les enquêtes de terrain. L'analyse documentaire a permis de faire le point des recherches sur la dégradation de l'environnement et leurs impacts sur la santé des populations. L'observation du terrain, l'enquête par questionnaire auprès de 201 chefs de ménage et les entretiens avec les autorités de Bondoukou ont permis d'avoir des informations sur la problématique de l'assainissement des eaux usées et pluviales et ensuite, les impacts de la gestion défectueuse des déchets liquides sur la santé des populations. Les résultats obtenus de cette étude montre que les quartiers n'ont pas les mêmes niveaux de dégradation. Il y a une corrélation forte entre la qualité de l'environnement des ménages et la prévalence des pathologies environnementales. Les pathologies les plus rencontrées sont les dermatoses (13,54 %), le paludisme (40,46 %), la fièvre typhoïde (3,76 %), les Infections Respiratoires Aigües (05,64 %), la diarrhée (29,59 %), la conjonctivite (05,46%), la bilharziose (0,48%) et les autres maladies (1,07%).
***Mots-clés :** Bondoukou, assainissement, gestion des déchets, santé des populations, environnement.*

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I. Introduction

Urbanization in developing countries is a concern, as 150,000 people are added to the urban population daily, attracted by the promise of a better quality of life (P. Chevalier, P. Gosselin, 2003, p. 9). From 5% before independence, the urbanization rate in Côte d'Ivoire rose from 42.5% in 1998 to 50.3% in 2014 (INS-RGPH, 2014). The population growth of Ivorian cities is spectacular and quasi-exponential with growth rates

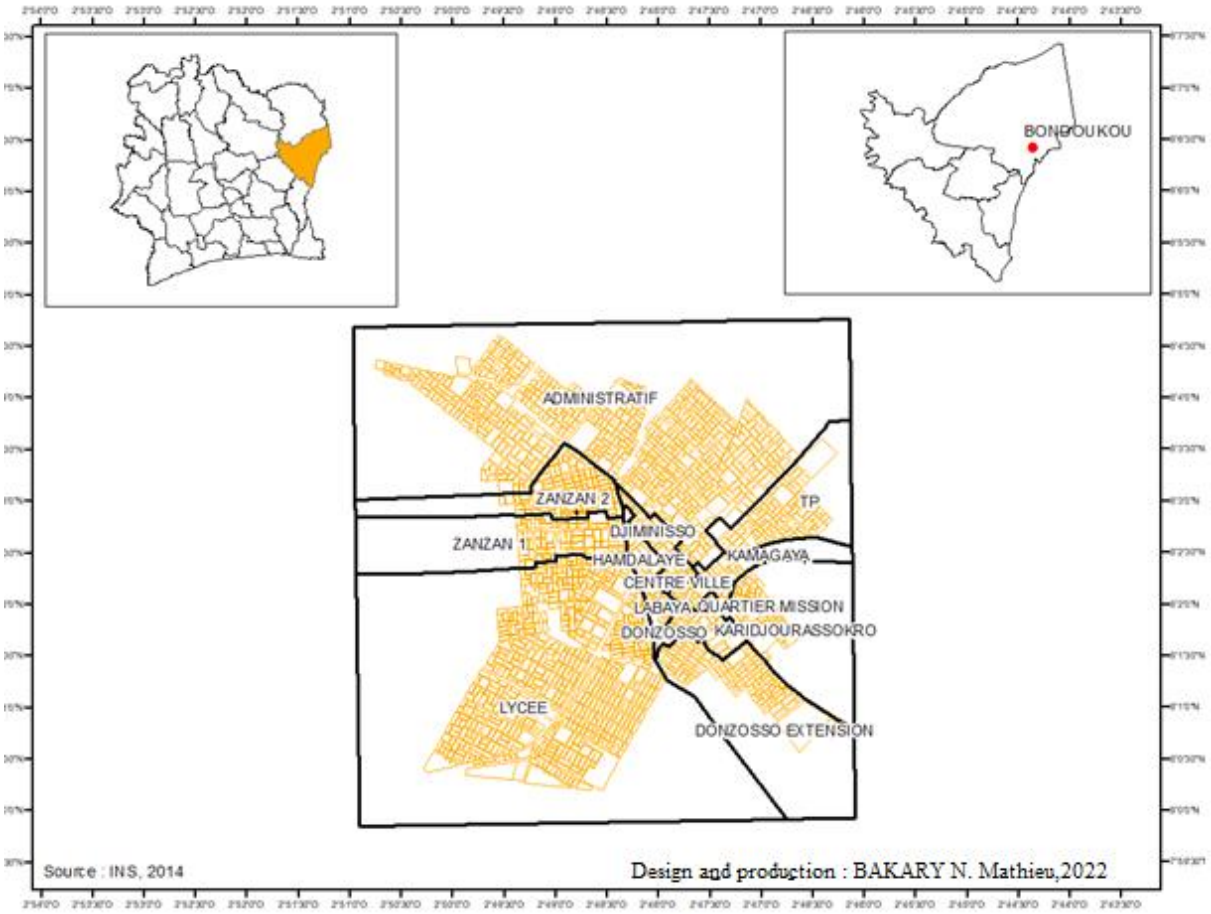
close to double the world average of 5.3% between 1988 and 1998 in Abidjan (Côte d'Ivoire). This population growth in Ivorian cities is confronted with several difficulties, including the problem of sanitation. Faced with this problem, the Ivorian State is making numerous efforts by setting up public sanitation infrastructures and promoting the establishment of decentralized structures in addition to the deconcentrated structures. The irrational management of wastewater and rainwater by these structures causes the degradation of the living environment. Thus, we are witnessing a generalized crisis in urban services, including the lack of drinking water supply for city dwellers, the failure of drainage infrastructure and sanitation (M. Coulibaly, D. Traoré, M. Coulibaly, B. Koné, K.P. Anoh, 2019, p. 411). The city of Bondoukou is not spared from these inconveniences. Dysfunctional liquid waste sanitation systems are noticeable throughout the city: wastewater stagnates in empty spaces, the roadway, and drains. Solid waste is irregularly removed and clogs the gutters, causing foul odors. The consequences of the dysfunctional sanitation systems on the living environment and the natural ecosystem are becoming more and more serious. Thus, in several districts of the city of Bondoukou, such as Kamgaya, Djiminisso, Balzac, etc., the very inadequate sewage works do not allow the evacuation of wastewater and rainwater. This difficulty explains the fact that liquid waste flows on the roads, in the open gutters and in the ravines adjacent to the houses. Bondoukou is developing in a context marked by problems of liquid waste management that result in health risks for the population. The health risks are related to the insalubrity resulting from precarious housing conditions and poor management of urban liquid waste (I. Sy, 2006, p. 256). An unhealthy space is a space that represents a health risk factor for the population. Faced with this living environment, the populations of the various neighborhoods of Bondoukou, and especially children, are exposed to several environmental pathologies such as malaria, acute respiratory infections (ARI), diarrhea, etc. The Ministry of Health and Public Hygiene (MSHP) report indicates that morbidity in children under 5 years of age in 2016 in Côte d'Ivoire was dominated by malaria (286.87‰), acute respiratory infections (175.01‰), anemia, diarrhea (88.51‰), malnutrition, and pertussis (MSHP, 2017).In Bondoukou, these impacts are also more significant. Faced with this bleak picture, the state has initiated emergency plans and put in place several strategies for garbage removal (S. Diabagaté, K. P. Konan, 2018, p. 126). Thus, the health of the populations appears as a synthetic indicator of the quality of the environment (K. Kouassi, 2013, p.47). So, to better understand this study, this question is necessary: What are the health risks related to the problem of sanitation in Bondoukou? This article aims to show that the health problem developed by the population is related to the management of wastewater and rainwater. Specifically, this study proposes to analyze the tools put in place to collect domestic wastewater and rainwater and the consequences of wastewater management on the health of the population in the city of Bondoukou.

II. Presentation of the study area and data collection techniques

2.1 Overview of the study area

The city of Bondoukou is located in the northeast of Côte d'Ivoire, between 8o02'23" north and 2o47' 54" west. Bondoukou is the capital of the administrative region of Gontougo. This city has 78,258 inhabitants (RGPH, 2014) for an area of 28.730 km2. The indigenous populations are the Abron, Koulango, Gbin, Nafana, Dêga as well as the Lobi of recent migration. Bondoukou is located in a Sahelian climate zone, characterized by a long rainy season (May-July) and a long dry season (November-April). The vegetation is made up of forest in the southern part, the density of which varies according to the degradation caused by agricultural clearing. In the center, there is a wooded savanna that gives way to a grassy savanna. The city of Bondoukou has a strategic position as a border city between Côte d'Ivoire and Ghana. Located 420 km away, the city of Bondoukou is bordered to the north by the departments of Nassian and Bouna. To the south, by the departments of Transua and Tanda. To the east by Ghana and to the west by the department of Sandegué, the regions of N'Zi and Iffou (Figure 1).

Figure 1: Location and presentation of the city of Bondoukou



2.2 Data collection techniques

The framework of the chosen methodology takes into account documentary research, field surveys and interviews. The documentary research made it possible to synthesize existing works on the subject of "Sanitation and population health" and to collect statistical data on the city of Bondoukou (North-East of Côte d'Ivoire). It took place in the following libraries and documentation centers: the library of the Institute of Tropical Geography (IGT), the Documentation Center of the Institute of Research for Development (IRD). This information is complemented by information provided by the technical department of the Bondoukou town hall regarding the management of liquid waste in the town. This information concerns the management of sanitation facilities or wastewater and rainwater management structures in the study area. Statistical data collected from the Bondoukou City Hall and the National Institute of Statistics (INS) were used to analyze the links between wastewater sanitation and the health of the population in the various districts of the city under study. The map of the city of Bondoukou allowed for a better understanding of the city, and then of the different neighborhoods in their boundaries with each other. It was processed in Adobe Illustrator / CS to constitute a new file to facilitate the realization then by the software Arc Gis 10.2.2.

In addition, the observation was participatory and allowed to verify the information contained in the literature in order to lay the foundations to help make a rigorous argumentation. The field survey took place from October to December 2021. It allowed us to verify the information contained in the literature review in order to better orient the study. Neighborhood chiefs, the head of the technical department of the Bondoukou town hall and other officials were interviewed about the management of rainwater and wastewater in their various neighborhoods and about the pathologies encountered. For the feasibility of the questionnaire survey, we proceeded by sampling, avoiding an exhaustive survey due to the saturation of information. To determine the sample size, that is, the number of people to be surveyed within the city of Bondoukou, the population survey; on 24,510 households (INS-RGPH, 2014) as a sampling frame, a questionnaire was administered to 244 statistical households. Fisher's law was used to calculate the sample size according to the following formula:

$$N_1 = \frac{t^2 \times P(1-P)}{m^2}$$

With : N1 = the sample size N1 = the size of the sample, t = the confidence rate that we wish to guarantee on the measurement ("at 90%", "standard value of 1.65"), p = the estimated prevalence of clients in each stratum and m = the margin of error that we give ourselves for the quantity that we wish to estimate ("margin of error at 10%", "standard value of 0.1") To compensate for the possible refusal of some respondents, we readjusted the size of our study sample. To compensate for the anticipated loss, it is important to multiply the sample size by the inverse of the response rates (Gumuchian et al., cited by KOKO Natacha, 2019, p. 58). For this study, the response rate is estimated to be 95%, so the adjusted sample size of households is: n= (244). The rationale for including all neighbourhoods in the city is that this method allowed spatial and social diversities to be highlighted in order to refine the analysis of the facts in order to achieve a better generalisation of the facts.
Household proportion = Number of representative households / Number of total households
Proportion of households = 246/24510 = 0.01003 = 1.003% = 0.1003 (INS-RGPH, 2014).
Number of households to be surveyed per neighbourhood = proportion of households × total number of households per neighbourhood. Example of the secondary school neighbourhood: the number of households to be surveyed = 2889 x 0.01003 = 29 (Table 1).

Table 1: Distribution of heads of households surveyed by neighborhoods in Bondoukou

Neighbourhoods	Number of heads of households (2014)	Sample size
MISSION	1541	15
CENTRE-VILLE	1404	14
KARIJOURASSOKRO	1784	18
KAMAGAYA	1977	20
HAMDALAYE	859	09
DJIMISSO	3029	30
ADMINISTRATIF	2294	23
TP	606	06
ZANZAN 2	4036	40
ZANZAN 1	1142	11
LYCEE	2889	29
LABAYAI	1118	11
DONZOSSO EXTENSION	898	09
DONZOSSO	933	09
TOTAL	24510	244

Source: INS-RGPH, 2014
At the end of the surveys, all the data were processed using the computer tool Epi-dada, Excel, Word and Arc Gis. The Epi-dada software was used to create the data entry mask; Word and Excel were used to enter the text and produce the graphs, while Arc Gis 10.2.2 was used to produce the maps.

III. Results

The analysis of the results concerns the sanitation facilities, the methods of disposal of domestic wastewater and excreta, and the health risks arising from the poor management of wastewater and rainwater.

3.1. Rainwater sanitation facilities in Bondoukou: a predominance of the individual or autonomous sanitation system

In the city of Bondoukou, the lack of a collective sanitation system has given way to an autonomous management of rainwater. In addition, the existing public sanitation structures are essentially made up of gutters for the purpose of evacuating rainwater. The gutters are unevenly distributed in the city. 89.38% of the respondents stated that the gutters are located in the city centre to the detriment of the peripheral neighbourhoods which have no gutters. 10.62% of the respondents did not object to the disparity of the gutters, but maintained that the peripheral neighbourhoods had unconstructed gutters (ravines) that did not favour the flow of rainwater (Table 2).

Table 2: Distribution of household heads by method of rainwater disposal

Methods of rainwater disposal	Number of households	
	Number	Proportion (%)
Drainage to gutters	28	11,47
Drainage to gullies	85	34,84
Drainage to streets	131	53,69
TOTAL	244	100

Source: Personal survey, 2021

The analysis in Table 2 shows the different methods of rainwater evacuation. The proportion of heads of households surveyed who stated that they evacuate rainwater through gutters was 11.47%. The majority of households (53.69% of all respondents) believe that they evacuate rainwater into the streets. This method greatly degrades the living environment in general and the roadway in particular, especially the unsealed roadway (see photograph 1) where the road is heavily eroded. The second largest proportion, with 34.84% of all respondents, is that which drains rainwater into gullies. This method is often supported by the city authorities. They build gutters or drains to facilitate the flow of rainwater into the gullies (photograph 2).

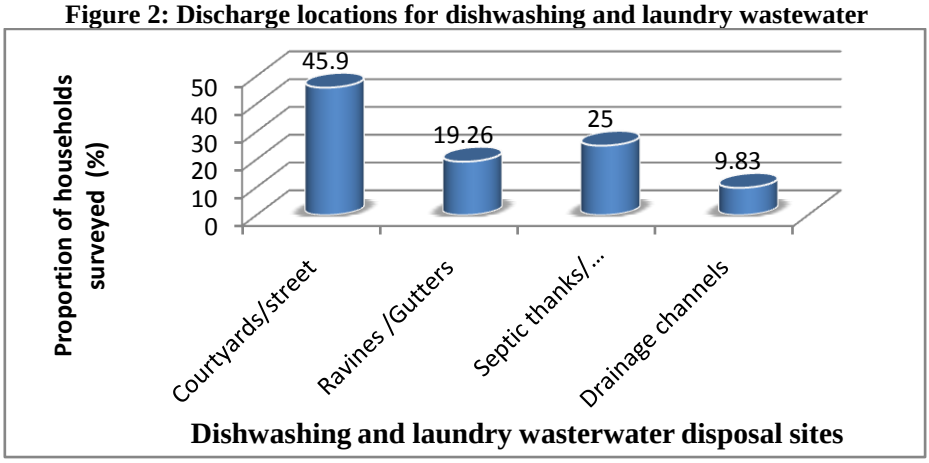
Photo 1: Road completelyeroded by rainwater in the Karijourassokroneighbourhood (Shot: Bakary Nambahigué Mathieu, 2021)

Photo 2: Presence of rainwater in a low-lying area through a gutter in the Donzosso district (Shot: Bakary Nambahigué Mathieu, 2021)

3.2. Drainage of wastewater from washing up and laundry: a difficult equation for the population

The evacuation of wastewater from washing up and laundry in the town of Bondoukou in 2021 has been difficult for the population (figure 2).

Figure 2: Discharge locations for dishwashing and laundry wastewater



Source: Personal survey, 2021

Figure 2 shows the practices of the population with regard to the discharge of wastewater from dishes and laundry. To discharge their wastewater, households use courtyards or streets, gullies or gullies, gutters and septic tanks. Yards or streets (45.90%) remain the most common means of discharging household wastewater. Septic tanks or cesspools are in second place with a proportion of 25% of households surveyed. Finally, gullies and gutters come third and fourth respectively with proportions of 19.26% and 9.83% of respondents. Photographs 3 and 4 clearly illustrate the behaviour of the people of Bondoukou when it comes to choosing places to dispose of wastewater from dishes and laundry.

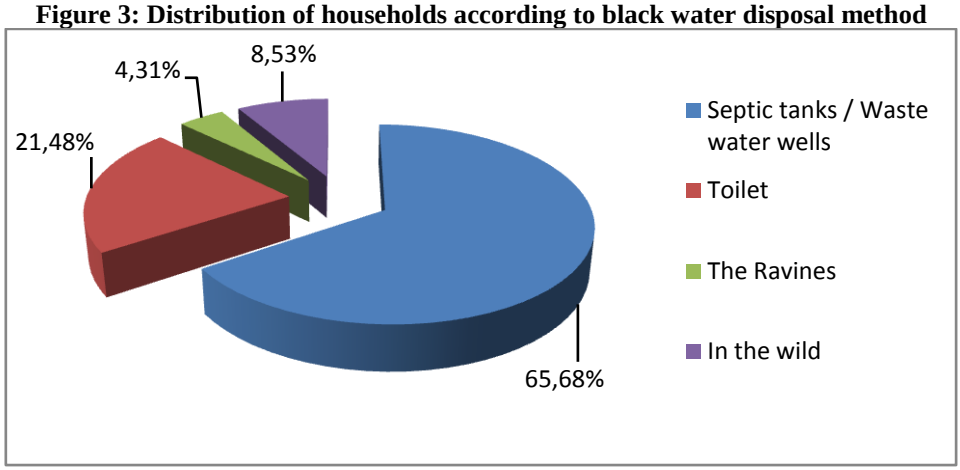
Photo 3: A youngwomanpouringwastewaterinto a gutter in the Labaya district (Shot: Bakary Nambahigué Mathieu, 2021)

Photo 4: Wastewater in the streetafterwashing in the Hamdalye district. (Shot: Bakary Nambahigué Mathieu, 2021)

2.3. Blackwater management methods

The results obtained during the field surveys on black water management methods are highlighted in Figure 3.

Figure 3: Distribution of households according to black water disposal method



Source: Personal field survey, 2021

The analysis in Figure 3 shows the way people in Bondoukou discharge black water. This method of disposal is not adequate in view of the septic tanks that are not maintained (photo 6). The 65.68% of heads of household surveyed stated that they evacuate black water into septic tanks. However, when these tanks are filled or damaged, the water flows behind the concessions or into the streets, causing foul odours (see photos 5 and 6). These unhealthy places become breeding grounds for malaria vectors, which are none other than mosquitoes. Latrines (21.48%) are the second most common place where black water is evacuated by all the respondents. Nature and gullies are also used by the city's populations for wastewater disposal, with proportions of 8.53% and 4.31% respectively.

Photo 5: Presence of wastewater behind a house in Kamagaha district. (Shot: Bakary Nambahigué Mathieu, 2021)

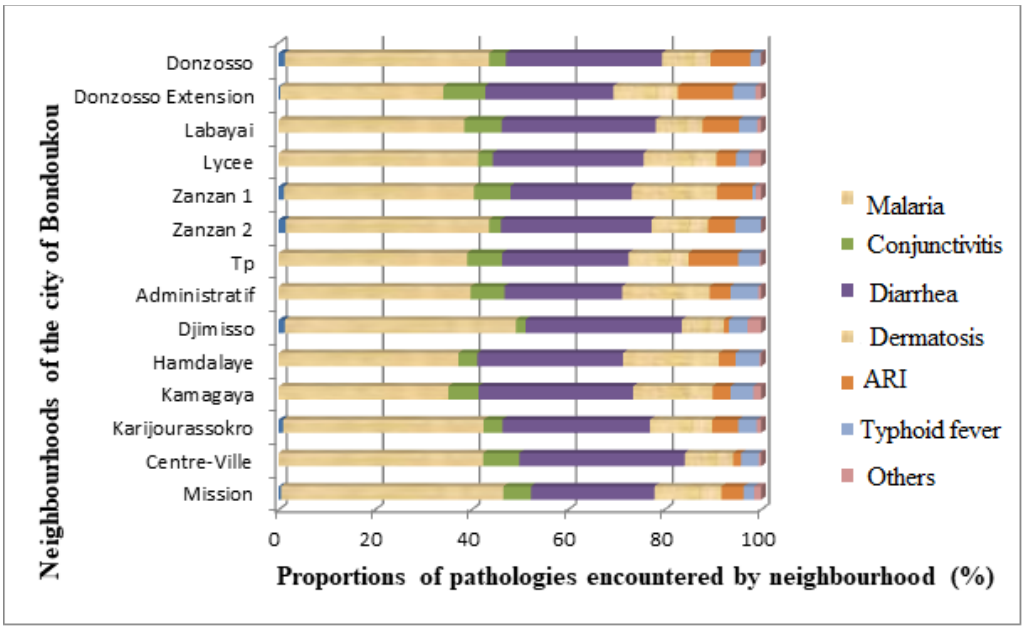
Photo 6: An open septic tank with black water flowing in a concession in the Djimisso district (Shot: Bakary Nambahigué Mathieu, 2021)

2.4. The impact of wastewater on the health of the population

In the town of Bondoukou, the symptoms of illnesses observed in households in the various districts and the pathologies recorded in the health records are dominated by malaria (40.46%). Malaria is the primary cause of consultation for patients, especially children aged between 0 and 5 years. The Djimisso district

(47.89%) has the most cases of malaria, followed by the Centre-ville district with 42.35%. Diarrhoea, with a proportion of 29.59%, is the second most common pathology diagnosed among the patients presented by the heads of household. At the neighbourhood level, the Centre-Ville neighbourhood (34.25%) is the most affected. It is followed by the Djimisso district. Dermatosis, with 13.54%, is the third most common environmental disease in Bondoukou. It is followed by Acute Respiratory Infections (ARI) with a proportion of 05.64%. Conjunctivitis and yellow fever occupy fifth and sixth place respectively among environmental diseases in the city. Other diseases (1.07%) and bilharzia (0.48%) close the circle (see Figure 4).

Figure 4: Main pathologies encountered by the population in the different districts of the city of Bondoukou

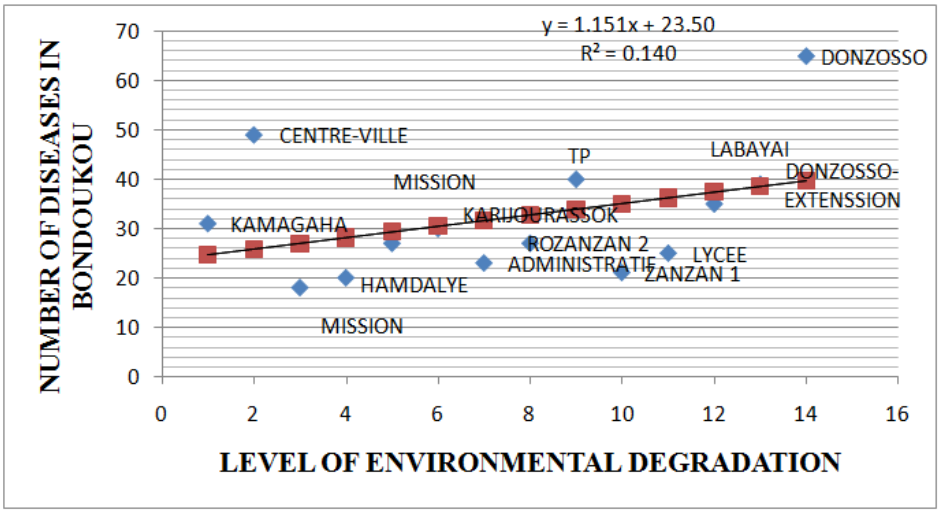


Source: Personal field survey, 2021

2.5. Link between the level of degradation caused by the wastewater management method and the health status of the population.

The linkage required the use of a choice of statistical tools, notably "r". Figure 5 shows this correlation. In this linear correlation, the explanatory variable is the level of environmental degradation and the explained variable is the number of sick people. Figure 5 shows that the two variables move in the same direction, which means that the more the environment is degraded by household and black water, the more the number of sick people related to the environment increases.

Figure 5: Correlation between the level of environmental degradation and environmental pathologies



Source: Personal field survey, 2021

The analysis of figure 5 shows that the dynamics of the level of insalubrity is highlighted through the linear regression line Y=1.1516x + 23.505. Thus, the sign of the directing coefficient of this straight line equation shows that the number of patients increases proportionally with the level of degradation of the neighbourhoods. In Bondoukou, the coefficient of determination r2 = 0.1406 for this linear correlation and the r = 0.3749 are between 0.3 and 1, which shows that there is a very strong link (Christine Dufour, 2018) between the level of environmental degradation and environmental diseases. This is clearly seen in several neighbourhoods in the city of Bondoukou, including Kamagaha, Tp, Donzosso, Labayai, etc. Finally, for a number of degrees of freedom of 3, the r read in the Pearson table is 0.30 while the calculated "r" is 0.37. After comparison, the calculated "r" is higher than the read "r". The coefficient of determination (r2 = 0.1406) shows a very strong correlation between the level of insalubrity and the incidence of pathologies.

IV. Discussion

Sanitation problems are acute in the city of Bondoukou due to the lack of control of urban dynamics. Indeed, the study shows that the lack of a collective sanitation system has given way to an autonomous management of rainwater in the city. The existing public sanitation facilities are essentially made up of gutters for the purpose of evacuating rainwater. In addition, 89.38% of the gutters are located in the districts located in the centre of the city to the detriment of the peripheral districts which do not have any gutter. In the same vein, K. C. Kouadio, N. M. Bakary, P. Tuo, K. P. Anoh (2019, P.142) show that the network does not cover the whole town of Bingerville and is non-functional in some places. At the SICOGI 2 crossroads, the household wastewater drainage system has become obsolete and leads to run-off through the canal reserved for rainwater drainage. This observation will lead N. M. Bakary, K. C. Kouadio, P. Tuo, K. P. Anoh (2019, P.475) to state that the general sanitation situation in the Ivorian context is not very good. E. Ngwe (1999, p.4) corroborates this result when he also showed that Yaoundé does not have a general sanitation network. Furthermore, the study shows that 11.47% of the heads of households surveyed attest to evacuating rainwater through gutters and 53.69% of all respondents evacuate rainwater into the streets. This method greatly degrades the living environment in general and the roads in particular, especially the unpaved ones (highly eroded roads). The second largest proportion, with 34.84% of all respondents, is that which evacuates rainwater into the gullies. To discharge their wastewater, households use courtyards or streets, gullies or gullies, gutters and septic tanks. Yards or streets (45.90%) remain the most common means of discharging household wastewater. Septic tanks or cesspools are in second place with a proportion of 25% of households surveyed. Finally, gullies and gutters come third and fourth respectively with proportions of 19.26% and 9.83% of respondents. Similarly, the results of the survey conducted by (S. K. Ouattara, B. Kambiré and M. Ymba, 2018, p. 409) show that in Songon-Agban, 93% of households discharge their washing and dishwashing water into the street or into nature. The results obtained are similar to those of P. Tuo, K. C. Kouadio, M. Coulibaly, K. P. Anoh (2016, p.177) in Dabou. Furthermore, the lack of a sanitation and wastewater disposal system has an impact on the quality of the environment, the living environment and the health of the population (UN-Habitat, 2012, p.24). The reasons put forward by (N. M. Bakary, 2016, p.188) are that the material and financial resources of local authorities do not keep up with the quantitative evolution of waste, so the management of this waste is a cause for concern. Following this observation, the study shows that the symptoms of diseases observed at household level in the various districts of Bondoukou and the pathologies recorded through the health booklets are dominated by malaria (40.46%). Malaria is the first cause of consultation of patients, especially children between 0 and 5 years of age. The Djimisso district (47.89%) has the most cases of malaria, followed by the Centre-ville district with 42.35%. Diarrhoea, with a proportion of 29.59%, is the second most common pathology diagnosed among the patients presented by the heads of household. At the neighbourhood level, the Centre-Ville neighbourhood (34.25%) is the most affected. In sum, the study shows that the inadequacy of sanitation facilities and the defective management of wastewater and rainwater expose the city's populations to environmental pathologies. Malaria (40.46%), ARI (05.64%), diarrhoea (29.59%), dermatoses (13.54%), typhoid fever (03.76%), conjunctivitis (05.46%), and bilharzia (0.48%) are the main pathologies suffered by the populations of Bondoukou. For I. Sy (2006, p. 478), the high incidence of diarrhoea can be explained by the interactions between all the factors of the local environment, housing conditions, socio-economic conditions, behavioural factors and socio-demographic factors. The study shows that through the different statistics and through the linear regression method that there is a correlation between the level of degradation of the living environment (presence or not of sanitation system) and the health of the population of Bondoukou.

V. Conclusion:

This study has established a link between the management of liquid household waste and the health of the population in the city of Bondoukou. The inadequacy of sanitation facilities and the defective management of wastewater and rainwater expose the city's populations to environmental pathologies. Malaria (40.46%), ARI (05.64%), diarrhoea (29.59%), dermatoses (13.54%), typhoid fever (03.76%), conjunctivitis (05.46%), and

bilharzia (0.48%) are the main pathologies suffered by the population of Bondoukou. The linear regression method shows that there is a correlation between the level of environmental degradation and the health of the population. The issue of sanitation must be a priority for the population and the state authorities. For the development of Bondoukou, the State must take many actions by building many sanitation facilities according to the dynamics of the city and the people in charge of the state structures must raise awareness of the population in terms of liquid waste management in urban areas.

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