

# Environmental Sanitation and Health Risks in Tropical Urban Settings: Case Study of Household Refuse and Diarrhea in Yaoundé-Cameroon

H. B. Nguendo Yongsi, Thora M. Herrmann, A. Lutumba Ntetu, Rémy Sietchiping, Christopher Bryant

**Abstract**—Health problems linked to urban growth are current major concerns of developing countries. In 2002 and 2005, an interdisciplinary program “Populations et Espaces à Risques SANitaires” (PERSAN) was set up under the patronage of the Development and Research Institute. Centered on health in Cameroon’s urban environment, the program mainly sought to (i) identify diarrhoea risk factors in Yaoundé, (ii) to measure their prevalence and apprehend their spatial distribution. The cross-sectional epidemiological study that was carried out revealed a diarrheic prevalence of 14.4% (437 cases of diarrhoea on the 3,034 children examined). Also, among risk factors studied, household refuse management methods used by city dwellers were statistically associated to these diarrhoeas. Moreover, it happened that levels of diarrhoeal attacks varied consistently from one neighbourhood to another because of the discrepancy urbanization process of the Yaoundé metropolis.

**Keywords**—Diarrhea, health risk, household refuses handling, sanitation, Yaoundé.

## I. INTRODUCTION

THE rapid urbanization of our planet dates back to the 19<sup>th</sup> century. In 1950, 29% of the world’s population lived in the cities. This figure is currently estimated to 50% and it is projected that by 2030, this proportion will reach 61% [1]. More intriguing than these global figures is the rapid and spectacular process within developing countries in general and Africa in particular.

Urbanization in Africa has been phenomenal and puzzling with a rapid shift from 15% in 1950 to about 41% urban currently. It is estimated that by 2030, the continent may attain 54% urban proportion [1]. Not only are there more people living in cities but the cities themselves are becoming larger and more numerous. There are now 43 cities in Africa with

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populations of more than one million inhabitants, a figure that is expected to rise to almost 70 by 2015.

This phenomenal growth has been qualified variously as “galloping” and “wild” [2] to express not only the uncontrolled nature of urban growth, but also the ecological and sanitary consequences often associated with the growth and the implications they may have on human health and well-being [3]-[4]. Health and well-being concerns of inhabitants of developing societies are linked to –or associated with– the unplanned urban centers [5].

In Sub-Saharan Africa for instance, setting adequate socio-urban facilities at the disposal of all and everyone --- such as sanitation infrastructures --- is a challenge to policy makers. In fact, because of slow economic growth, lack of sound development policies and an increasing number of small households, infrastructure development has been unable to keep up with the burgeoning need for shelter and services for the growing urban populations [6]. As a result, many African cities have an increasing number of overcrowded, informal settlements characterized by inadequate housing and poor provision of infrastructures such as water supplies, sanitation and waste management services [7].

Such is the case in Yaoundé where urbanization continues to figure as a puzzling issue in the sense that urban growth and the socio-sanitary consequences often associated are key elements of difficulties and health concerns the city currently faces. Hence, local government authorities have failed to provide dwellers with infrastructures related to the management of household refuses i.e. collection, transportation, processing, recycling or disposal of waste materials.

This provision failure has led to a disappointing situation in terms of household refuse collection and disposal. Indeed, the city’s accelerated and uncontrolled development led to a proliferation of independent household refuse collection and disposal systems in the capital’s various neighbourhoods where these systems have a significant impact on the health of the various populations.

In this regard, these disposal methods can no longer simply be considered amenities, but rather nuisances as health risks they impose on the urbanites are rather significant. Cases of infectious diarrhoeas’ identified in the city and whose

prevalence was linked to mismanagement of household refuse is proof of this.

This paper reports on a 2002 and 2005 epidemiological cross-sectional study of household refuse management practices in Yaoundé. First, a presentation of the spatial and methodological framework of the research provides a background. The city's household refuse problem is then addressed. Finally, the household refuse and the diarrheic risks assumed are presented simultaneously.

## II. MATERIAL AND METHODS

### A. Conceptual Framework

In developing countries and countries with economies in transition, waste management often emerges as a problem that endangers human health and the environment. To make matters worse, waste management usually has a low priority on the political agenda of such countries, as they are struggling with other important issues such as hunger, health problems, water shortages, unemployment and even civil war! In such situations, it is easy to understand why waste problems have a tendency to grow steadily. Fast-growing population, poverty of large numbers of urban households, and persistent deterioration of living conditions are some of the challenges facing cities of the developing world [8] -[9].

For at least four decades, a wide-ranging research effort has investigated the cost-benefits of providing safe and convenient living conditions to households in the developing world [10]. Most of the work has focused on housing conditions, notably on the relationship between water, sanitation and disease [11]-[12]. Research notes that water supply, sanitation and health are closely related. It is also evident that each year, poor hygiene, mismanagement of liquid or solid waste, and lack of sanitation facilities contribute to the death of millions of the world's poorest people from preventable diseases [13]. Considering the nexus cleansing/sanitation and health, empirical evidence points to their close linkages. In particular, the relationship could be outlined as follows:

(a) As cities continue to grow, the management of solid waste is becoming a major environmental and public health concern in urban areas of many developing countries [14];

(b) Lack of sanitation, unsafe disposal or storage of waste in/around houses and streets, and in undesignated containers may provide habitats for vectors of that cause various infectious diseases including amebiasis, typhoid fever and diarrhoeas [15];

(c) Uncontrolled landfills are a huge danger for the surrounding environment and are a health risk to the population, causing contamination of the drinking water and soil [16];

(d) More than five million people die each year from diseases related to inadequate waste disposal systems [17];

It is estimated that 1.8 million people die worldwide every year from diarrhoeal diseases (including cholera). Amongst them, 90 % are children under 5 mostly in developing societies. An estimated 88% of this burden is attributed to unsafe drinking water supply, inadequate sanitation, and poor hygiene [18]. These risk factors do not evenly threaten urban districts as slums and informal settlements are more vulnerable to communicable diseases [19]-[20].

Despite the quantity of studies carried out, relatively little is known about the key contribution of waste management in diarrhoeal incidence. In particular, households' refuse has rarely been examined. Among the regions of the world, Sub-Saharan Africa needs to fill the research gaps in the area, especially because the region has the fastest growing urban population and the majority of city dwellers have least access to urban equipments [21]-[22]. Under this backdrop, this paper examines health outcomes in the context of rapid urban population growth without adequate accompanying services and infrastructure.

Our focus is on infectious diarrhoeas with particular reference to household refuse handling in Yaoundé. From the health geography stand point, urban and rural areas do not experience health hazards with an equal magnitude [23]. This study argues that incidence and prevalence rate of diarrhoeal diseases in Yaoundé vary according to household refuse handling methods. Household refuse and diarrheas are key concepts in this paper. Household refuse here refers to domestic rubbish such as organic trashes. Thus, hazardous industrial, commercial, hospital, construction wastes are outside our scope. Following clinical signs, we have considered diarrhea as the sudden and frequent occurrence of abundant and consistently abnormal watery or mucus stools more than three times a day and more than 300g per stool [24]-[25]. The stools should be mixed with a phlegm-like substance or blood, and are associated with dysentery. To indicate its acute character, the episode must last for about 14 days.

### B. Study Area: Choice Justification

Our study deals with the City of Yaoundé, located in Central Africa, under tropical latitudes slightly above the equator. More specifically, she's situated between latitudes 3°47' and 3°56' N and 11° 10' and 11°45' E, approximately 250 km from the Atlantic coast (Fig. 1).

Yaoundé experiences a typical classic Equatorial Guinean climate: regular and abundant precipitations (1,600 mm/ year), an average annual temperature of 23°C, existence of four seasons i.e. two "dry" seasons and two rainy seasons.

Like many sub Saharan African cities, Yaoundé is currently experiencing very rapid urbanization. In 1926, date of the first population census, Yaoundé had 100 000 inhabitants. With an estimated annual growth rate of 4.5 per cent since 1980, urban population has grown from 812,000 inhabitants in 1987 to 1,500,000 inhabitants in 2000, and to about 2,100,000 inhabitants in 2006 [26].

However, this population growth has not been monitored by the city planners and decision makers. Consequently local authorities have failed to provide neighborhoods with adequate utilities, services and infrastructure. Therefore, city dwellers are living without a waste management system as they do not have access to garbage collection, and to suitable waste containers.

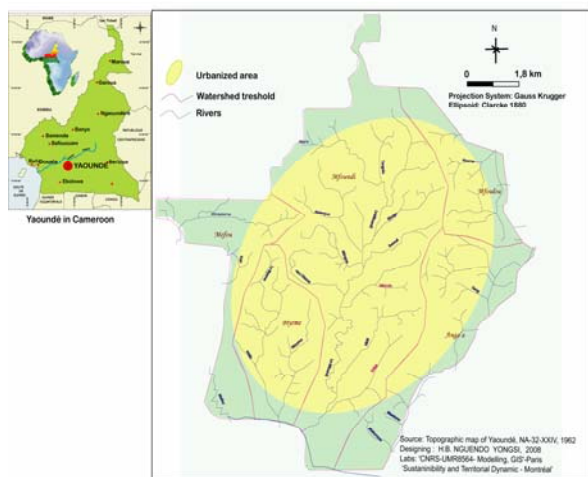


Fig. 1 Location of Yaoundé, Cameroon

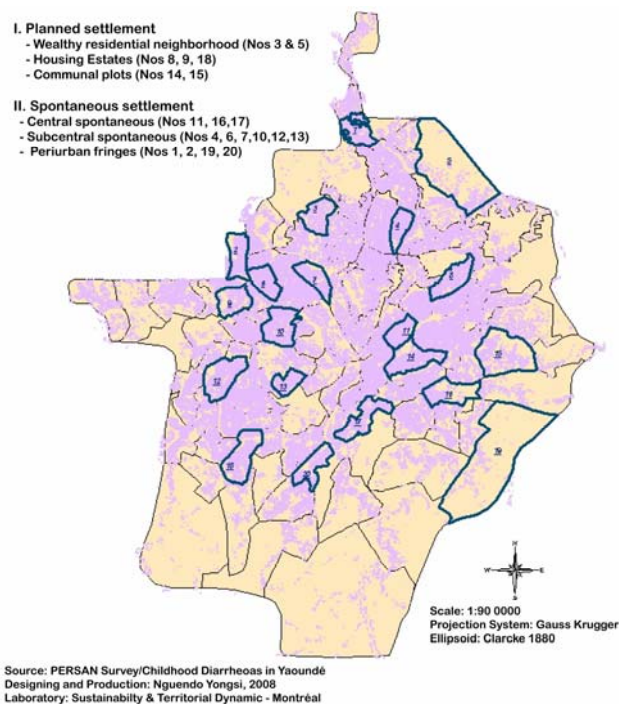


Fig. 2 (a) Selected neighborhoods

### C. Data and Methods

Data presented herein is taken from the Yaoundé Urban Council and from an interdisciplinary research program conducted by us in 2002 and 2005.

#### (i) Data Collection

■ **Target population:** In order to minimize the risk of confusion between infectious diarrhoeas and the soft stools normally observed in infants, the study only targeted children aged 6 to 59 months. Hence, households with no children or whose children do not meet the age criterion were not considered for sampling purposes. In households in which there were several children within this age range, a random age table allowed for the selection of one single infant. This need for only one child per household stems from the study's specificity, which wanted to focus the analysis on a smaller scale, the household or lot.

■ **Survey frame and type:** The survey covered neighborhoods and households in Yaoundé, and used a stratified random sampling procedure based on two stages to select targeted neighborhoods. First, 20 neighborhoods were selected out of the 105 that make up the city. This was necessary to derive a sample size sufficient for the scientific validation of the results. These neighborhoods were representative of the six types that Yaoundé displays (Figure 2a). In the second stage of the survey, we selected 3,034 households. Households were selected on the basis of having a child of less than 5 years of age as they appear to be more vulnerable to infectious diseases (Fig. 2b).

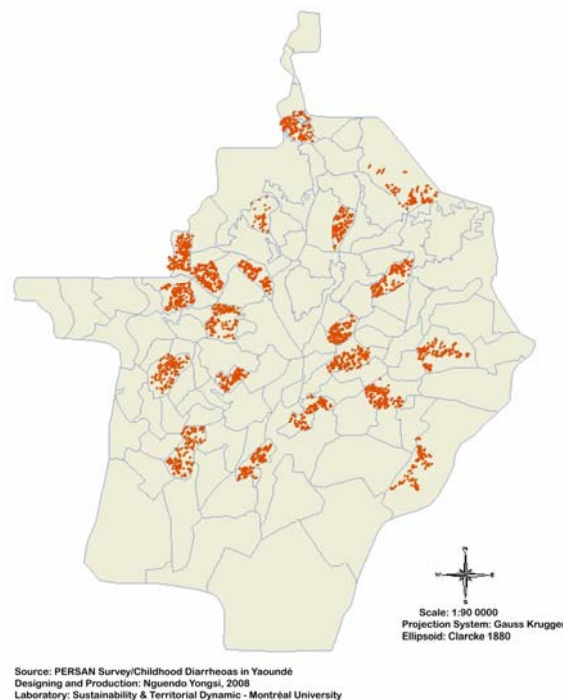


Fig. 2 (b) Surveyed households with fewer than five years children

The survey was conducted by a team of final year students of the Faculty of Medicine and Biomedical Sciences and by surveyors specialized in population studies of the Cameroonian National Institute of Demography. The team visited the selected households to collect data using (i) direct participative observation technique and (ii) structured questionnaires drawn up to respond to the two dimensions of this study, namely:

- The socio-demographic and environmental dimension: Covered by 63 questions and items, this aimed at (i) examining how refuse is handled, and (ii) at characterizing living conditions of households within the selected districts.
- The medical dimension: approved by the National Ethics Committee of Cameroon, this dimension targeted children of less than five years in the sampled households and aimed to detect cases of diarrhea in children within the selected households. Thus, when a case of diarrhea was reported, a stool sample was taken and dispatched to the bacteriological, virological and parasitological laboratories of the Cameroon Pasteur Institute within the accepted requirements, for confirmation and identification of the causal germs. Each positive sample was linked with the household's socio-environmental data. These data files were spatially analyzed using the Geographical Information System method. Bivariate statistical analyses and tests of significance were carried out to verify level of association between the two variables i.e. diarrheas and household refuse management method(s).

■ *Data collection period:* One of the goals of this study was to pinpoint, if necessary, diarrhoeas seasonality within the city and thus evaluate its incidence. This is why two visits were planned: one during the rainy season and the other during the dry season. That said, budgetary cuts forced us to limit ourselves to only one visit. This visit was made during the months of April, May or June, which correspond to the city's rainy season.

#### (ii) Level of Analysis

Several factors are involved in diarrhoeal prevalence in Yaoundé [27]. However, our objective is far from drawing a hierarchy of those factors. Rather, we intend to assess household refuse management practices on the city dweller's health.

Thus, analysis hereby done is merely contextual i.e. 'household refuse management method' variable is analyzed without any consideration for the other variables, obviously linked as well but not part of the selected analysis theme.

This attitude is set by problems linked to geographical explanations and by the diversity of scientific reasonings that geographers must nowadays take into account<sup>2</sup>. Indeed, given expansion of geography field, it is important --- within an explanation and demonstration process --- to isolate each risk factor so as to open out into a system through the multivariate analysis. Hence, statistical measure used to assess the association level between variables (refuse collection/disposal methods and diarrhoeas) is the bivariate analysis. It has been reinforced through the signification tests.

### III. YAOUNDÉ, A DEVELOPING CITY FILLED WITH HOUSEHOLD REFUSES

By household refuses we mean any trash and food residues, substances, materials, products that households get rid of. Are also added, mud and animal droppings. Like other developing

cities, Yaoundé is marked by piles of garbage on the sidewalks and homes exterior premises [28].

A situation that is quite different from the one that prevailed during the German colonial period: "On the plateaus, numerous European constructions stand tall, and they are streaked by clean well-defined roads and avenues crossing in every direction and lined with trees..." [29].

In Cameroon's main metropolises, municipal waste collection rate does not exceed 60%. In Yaoundé for example, between 1991 and 1998, this rate was of approximately 15% [30]. The service was then concentrated in the downtown area, excluding the pericentral and peripheral neighbourhoods even though they were the most populated. This situation was so problematic that almost all of the urban space was congested with all kinds of garbage. Yaoundé had become a "garbage town", the "dump capital".

Urbanites then started to become more aware of the salubrity problem surrounding them. Indeed, gathering features of a shabby and polluted city, the urbanites began wondering as they were not used to such an unhealthy situation since the independence<sup>3</sup>. In any event, faced with garbage proliferation which engaged the city in an agony process and whose severity was finally accepted by municipal authorities, some ministerial commissions for household refuse management were created in 1997.

These commissions came into evidence that difficulties linked to household refuse management, as for all municipal solid and liquid waste, were complex and multileveled: (a) *institutional* (lack of regulations and presence of multiple actors with ambiguous skills)<sup>4</sup>, (b) *financial* (weakness of the taxes collected)<sup>5</sup> and (c) *technical* (failure to master appropriate techniques and lack of related standards) [31].

This explains why expectations and attitudes were and are still different: whereas households simply want to get rid of their waste, local government wants to ensure public salubrity. These antagonist views have led to serious dysfunctions whose impacts on the urbanites' health are being revealed through a gradation of diarrhoeal diseases within the urban space.

Nowadays, Yaoundé produces some 1,076 tonnes of waste daily, of which only one third corresponds to the removal capacity of Cameroon's Sanitary Hygiene Services (HYSACAM). That is, an average production of 0.85 kg/j/inhabitant and an annual production of 10,896 tonnes, corresponding to a mass density of 42,938 m<sup>3</sup> [32].

Like in other developing cities, these wastes are mostly made up of putrefying matters [33]-[34] and mostly produced in informal communities [35]-[36].

### IV. HOUSEHOLD REFUSE MANAGEMENT METHODS AND THE ASSOCIATED HEALTH RISK LEVELS

Household refuse management process is usually composed of four steps: precollection, collection, transportation and processing [37]. That said, we will only consider the first two as they are the ones dealing with

domestic and peri-domestic environments which are our two observation scales.

#### A. Precollection or Storage

Within the private framework of house organization, precollection is the operation through which households gather their garbage and dispose them outside. In other words, it is the preliminary storage within the domestic environment.

In Yaoundé, four storage methods have been observed (Table I). Use of open containers has appeared to be the most widespread method (82.3%). If we add households that use their lots as a storage area (3.4%) and those that say they do not take part in the precollection process (but who presumably collect their garbage on the lots), one can notice that most city dwellers do not well handle their refuses. Health risk incurred is significant [38].

Indeed, in the city, this method of storage has been statistically linked to diarrhoea incidence: nearly 87% of diarrhoea cases were done so in households that stored unprotected waste. This may be due to the fact that, stored in unhealthy conditions as they usually are (in boards, plastic bags, buckets that are usually dirty and left uncovered), these biodegradable household refuses generate a mushrooming environment for insects and rodents which are insalubrity indicators and pathogens host.

Given the proximity of humans, contamination may occur especially given the fact that this waste remains inside the houses several days before being taken out for disposal. This is a permanent situation in numerous developing cities [39]-[40].

TABLE I  
 WASTE STORAGE METHODS USED BY YAOUNDÉ  
 HOUSEHOLDS AND DIARRHEAS

Storage Method	Household Distribution	Percentage	Diarrhoea Cases
No storage	130	4.3	17
In a closed container (garbage)	295	9.77	35
In an open container	2,484	82.34	363
Piles in the backyard (lot)	108	3.59	15
Variable cover 99.43 (3,017)			

p < 0.05

Source: PERSAN Study / Infantile Diarrhoea in Yaoundé.

However, diarrhoea cases associated to household refuse collection on the lots do vary between the communities. As shown in Fig. 3, low rates are present in planned neighbourhoods (Bastos, Ngoussou, Cité Verte), regardless of the gathering methods. In contrast, the highest diarrhoea rates appear in the spontaneous neighbourhoods (Mokolo, Briqueterie) whose populations fall within the social and economic low category. Most households are so concerned with food survival that they pay little attention to storage material which many consider to be a futile luxury. In these informal neighbourhoods, households make use of used material collected from rivers and from rain drains (cracked plastics pails, old packing cases).

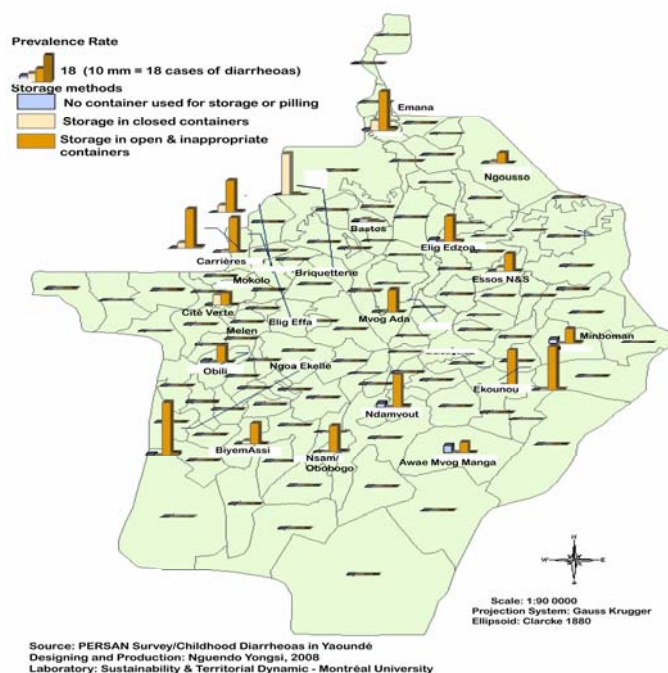


Fig. 3 Intraurban Variation of the Diarrheic Attack Level According to the Household Refuse Storage Methods

#### B. Disposal

By this, we mean set of operations during which container contents are emptied outside the homes before being transported to processing sites. In Yaoundé, this public utility is seriously dysfunctional and is faced with the institutional, financial and technical difficulties mentioned previously. This has led to the existence of several household refuse disposal methods within the city (Table II).

TABLE II  
 HOUSEHOLD REFUSE DISPOSAL METHODS IN YAOUNDÉ  
 AND DIARRHEAS

Method	Frequency	Percentage	Diarrhoea Cases
Home collection by HYSACAM	879	29.03	133, or 15.13%
Disposal in a garbage bin	1,047	34.58	136, or 12.99%
Disposal in natural environment	1,091	36.39	167, or 15.35%
Variable cover 99.4 (3,017)			

p < 0.01 ; Source: PERSAN Study / Infantile Diarrhoea in Yaoundé.

And according to a particular method, is associated a specific risk for health.

(i) *Home disposal*: a disposal method with a proven pathogenic risk. This is a door-to-door system that consists in collecting waste stored in containers placed in front of houses. This system dates back to the colonial period and is commonly used in African cities [41].

In Yaoundé, this door-to-door system is carried out by the private enterprise HYSACAM, which has been tasked for the cleaning and removal of household refuses in the whole city. Although this system is monitored by the local government, it

does not cover the whole urban community due to some difficulties (Box 0).

Therefore, an agreement has been signed between HYSACAM and the local government. This agreement confines this door-to-door system only to the downtown area, planned neighbourhoods and to communities settled around main urban streets.

Technically, household refuse cleaning and collection operations in these neighbourhoods are executed daily by teams of garbage collectors. Special trucks trek the streets every morning (between 9:00 and 11:00 AM) and honk to signal their arrival. People then came out and empty their refuses in the trucks. Garbage bins are also placed in these neighbourhoods to allow those who were absent or unable to take out their garbage so that another special truck will pick them up in the afternoon.

However, this is not true. We have noticed that these garbage bins are removed only twice a week.

The biweekly frequency of waste collection and cleaning in these neighbourhoods is such that waste stored in front of houses becomes a real nuisance and can be associated to the 15.13% diarrhoeal rate that has been detected in those neighbourhoods.

urban areas with well-developed streets networks such as communal allotments have benefited from bins.

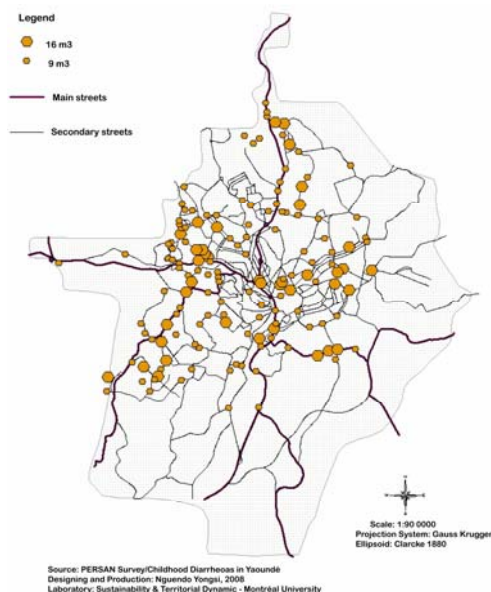


Fig. 4 Spatial Location of Garbage Bins and their Capacity

**Box 0: Municipal Household Refuse Collection in Yaoundé: A Failure Story**

Like most African cities south of the Sahara, Yaoundé presents a downtown area in which waste services reflect administrative difficulties to handle the problem. Only a historical approach can help better grasp household refuse management within the city. At the early ages of the independence i.e in 1960, household refuse collection and disposal were under control of the city's authorities. At the time, Yaoundé population was only 100,000 inhabitants, but the young municipality, in short of human and material resources was already having problems cleaning up the city. Consequently, waste was collected only in the city centre and in some surrounded residential neighbourhoods. In 1968, after the 1967 municipal reform, the Government tasked HYSACAM to clean the city on the basis of a 3-year contract, which has been regularly prorogated during 20 years. With the help of small companies such as ETRACAM and SCANID, HYSACAM ensured waste collection and disposal somewhat successfully, as only the downtown area and large urban centres were serviced, at the expense of the poor neighbourhoods. In 1991, the numerous outstanding payments accumulated by the national government led HYSACAM to stop its activities. Newly created districts municipalities took over in 1987. However, given the fact that each municipality only had one wide-beck excavator and two dump trucks to clean their respective jurisdiction, they were rather inoperative. Law No. 87/015 dated July 15, 1987 authorizing them to do so, they subcontracted waste management to various companies that, being unprepared for the collection task, also failed to ensure the cleanliness of the city. Failure of this collaborative approach opened up into proliferation of rubbishes and uncontrolled dumps in the city.

From 1992 to 1993, collaboration was experimented with the company SECA Inc, a subsidiary of HYSACAM. However, as with the previous collaborations, this one also failed mainly because of the lack of financial means. Yaoundé was then abandoned in all its waste and seemed to be disappearing under piles of garbage. This sad situation made the first pages of several local newspapers: "Yaoundé, dépôt-à-ciel ouvert" [Dikalo dated January 16, 1992], "Yaoundé, capitale-dépôt" [Le Jeune Observateur dated March 13, 1991], "Yaoundé, la ville qui se confond à ses tas d'ordures" [L'Effort Camerounais dated February 1992], etc. To meet the shortages in terms of public authorities, numerous NGO's and neighbourhood association were set up and invested in waste collection with rudimentary means. In March 1994, the Urban Community called on its NGO's to try to come up with coherent solutions to the problems. In November 1994, with the help of the World Bank and other funding agencies, the national government set up a collection system based on the use of numerous labours: this system was called "Programme Social d'Urgence" (PSU). For two years, it used nearly 1,700 idle persons. Fairly efficient, this programme proved to be temporally and technically limited. Its humble performance only succeeded in disposing of 15% of the total waste production. Furthermore, absence of a well-determined unloading site led each operator to unload the waste collected wherever it pleased, including shallow waters, thus creating other nuisances.

As part of the operation called "Yaoundé, healthy City", launched by the Ministry of Urban Affairs, HYSACAM returned as an active player in 1998 on the basis of a new private contract signed with the Urban Community, and dealing with waste collection throughout the city and sweeping operating on the main roads. In collaboration with the Yaoundé Urban Community, HYSACAM designed sweeping routes, distributed garbage bins and adopted a policy geared towards population sensitization by inviting them to put their garbage in the appropriate containers and sites. Despite these efforts, set goals were still not met. Various types of waste still lined streets of numerous urban neighbourhoods. Only 50 to 60 % of the waste was collected daily and as usual only in planned and structured neighbourhoods. The Urban Community has still not found a viable solution for the densely populated areas and the suburban neighbourhoods in which road networks are scarce.

(ii) *Waste deposit in garbage bins and drop in the natural milieu: disposal methods with contrasted pathogenic risks.* Theoretically, disposal in garbage bins affects all urban neighbourhoods. That is why HYSACAM which is responsible for waste collection has laid out garbage bins throughout the city. Unfortunately these garbage bins are unevenly distributed within the urban space (Fig. 4). Indeed, the collection route closely follows primary streets and some relatively functional secondary roads. Consequently, only

Moreover, these garbage bins are of weak capacity, have an insufficient amount<sup>6</sup> and are generally laid out at the end streets and on the crests: all the parameters that hamper their range (Fig. 5) and that oblige households from neighbourhoods excluded from this home collection system to resort to other alternatives experienced in other developing societies such as Pikine, Lagos and Jakarta [42]. These households either (a) empty their waste in dumps, in flood-prone areas or in the riverbeds, (b) or simply place grocery bags full of waste on the street to await collection, (c) or dig a waste hole behind houses to fill refuse, or (d) pile up waste outside houses and then set it on fire. Impact of spills is aggravated by the constant humid environment as rains quickly transform dumps into smelly cloacae in which proliferate flies and insects which are known to be carriers of contagious diseases like salmonellosis following foods contamination by flies and other winged insects.

With existing high temperature and humidity, putrid and biodegradable waste releases toxic substances. These substances infiltrate into and pollute groundwater many households collect to drink [43]-[44].

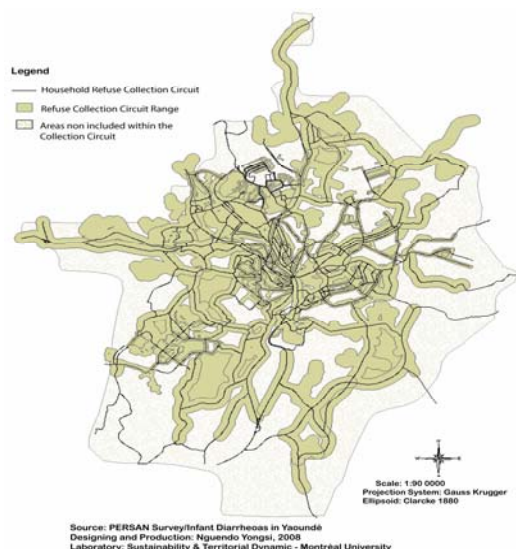


Fig. 5 Theoretical Range of the Household Refuse Collection Route

All these practices linked to bins overflowing pollute neighbourhoods through numerous household refuses riddling the outskirts studied households<sup>7</sup> (Fig. 6).

Following HYSACAM and Yaoundé Urban Authority inviting city dwellers to show civicism and responsibility in the management of household refuses ...

Household refuses were supposed to be placed in these garbage bins for collection and disposal. However, these bins are very small (9 m<sup>3</sup>) and are in dire conditions...

Consequently, these refuses are deposited directly along the roads where they form smelly piles, attracting flies and mosquitoes, and releasing liquid substances that infiltrate and pollute groundwaters.

Fig. 6 Household Refuses in Yaoundé

The microbiological analyses we conducted show that this groundwater contains a total mesophile flora of more than 10<sup>6</sup> UFC with huge quantities of coliforms and faecal streptococcus [45]. This unsafe water is suspected to be the cause of diarrhoeas' cases that have been identified (Table II, op cited).

#### V. SPATIAL DISPARITIES OF DIARRHEA

The pathogenic risk level related to household refuse management methods vary from one urban neighbourhood to another. Fig. 7 below shows that whatever the considered

disposal method, spontaneous neighbourhoods display the highest prevalence rates.

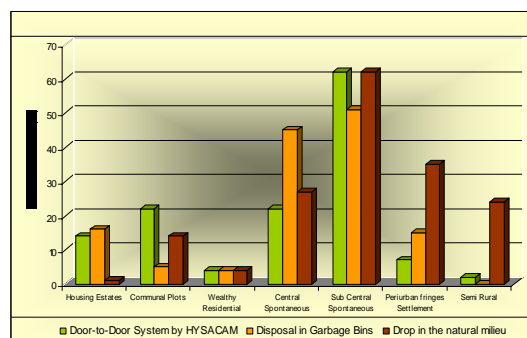


Fig. 7 Diarrheal Distribution among Surveyed Neighbourhoods

Of the 20 studied neighbourhoods, Figure 8 shows that diarrhoea prevalence rates are once more lower in the planned residential neighbourhoods (Ngoussou) than in the central and pericentral spontaneous neighbourhoods (Mvog Ada, Ekounou).

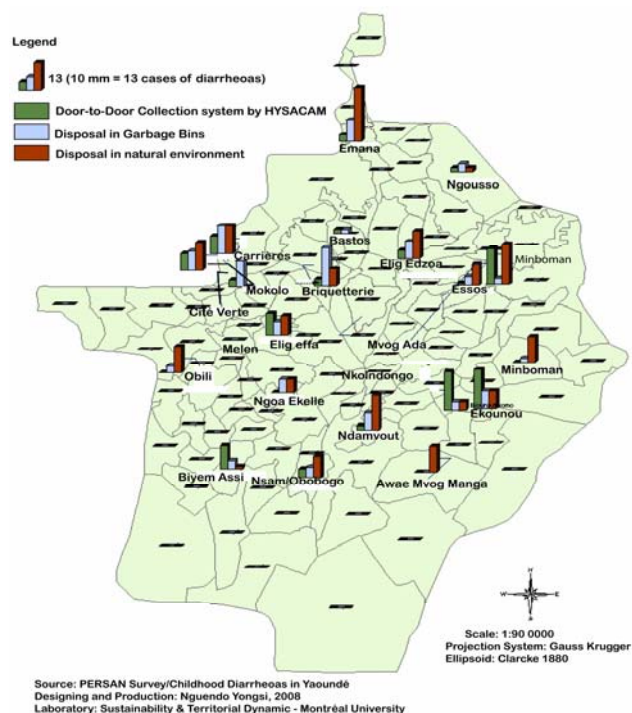


Fig. 8 Spatial Disparities of Diarrheic Attack Level According to Household Refuses Disposal Methods

#### VI. CONCLUSION

Presence of household refuses within Yaoundé neighbourhoods is persistent as well as in many developing cities [46]. Such a presence is a huge danger for the surrounding environment and is a health risk to the population, causing contamination of the drinking water and soil.

In Yaoundé, their presence and closeness to residents have been linked to numerous cases of diagnosed diarrhoeas.

These have expressed themselves in various ways depending on the way the household refuses are stored and disposed of: households that store their refuses carelessly (i.e. in open containers) are more vulnerable to diarrhoea attacks than households that use appropriate and regularly cleaned containers.

In the same way, households that take their garbage out on a regular basis to be collected and disposed of by the city's waste collection and disposal services are less vulnerable than those who do so less frequently.

On the spatial aspect, it was noticed that diarrhoeal cases were unevenly spread throughout and even within the neighbourhoods. These intra-urban disparities reveal the discriminatory character of the city's urbanization through the existence of areas and by the way populations more or less intensely vulnerable to diarrhoea risks: informal and less provided neighbourhoods exhibit high prevalence rates in contrast to the low rates noticed in planned neighbourhoods highly provided with soci-urban facilities.

This uneven prevalence thus sheds light on the issue of urban service management in developing cities [47]. Indeed, in developing cities, several ministries or national agencies are usually involved at least partially in solid waste management.

However, there are very often no clear roles of the various agencies defined in relation to solid waste management and also no single committee designated to coordinate activities.

This lack of coordination results in different ministries becoming the national counterpart to different external support NGO for different solid waste management collaborative projects without being aware of what other national NGO or agencies are doing. As Ogawa (2005) mentions, this «*leads to duplication of efforts, wasting of resources, and unsustainability of overall solid waste management programmes*».

As many city dwellers are living without a waste management system, a first step to improving this situation is to work out a phased technical and legal framework for waste management and then start the collection and disposal process, with the objective of continuously improving the system.

As we previously mentioned, the approach stemming from this work is the spatial distribution of diarrhoea risk factors and not development of an eco-epidemiological diarrhoea system. Proof is given by the contextual level of analysis we've adopted.

Consequently, it would be simplistic to associate diarrhoeal prevalence in Yaoundé solely to mismanagement of household refuses. It plays an important role but is far from explaining alone all diarrhoeal cases prevailing.

Other diarrhoeas' determinants do exist and can contribute understanding diarrhoeal prevalence. For a coherent view of a pathological unit as are diarrhoeal diseases, it is suggested to adopt a systemic approach using a multivariate or multilevel technique that integrates into one single model, all known risk factors.

#### NOTES

1. To avoid confusion between liquid stools that could signal presence of a certain food or drug allergy and typical diarrhoea-related stools, macroscopic and microscopic studies were conducted

on each stool sample collected to ensure that diagnosis actually provided corresponded to our understanding of diarrhoea, i.e. excessive amounts of liquid, soft or pasty stools during 3 to 5 consecutive days, accompanied by colic, tenesmus or fever.

2. There are four types of complexity in geography: (i) Complexity linked to a large number of components (physical dimension which includes geology, climatology, pedology, hydrology,...), (ii) Complexity through the nesting of spatial levels (observation and analysis scales), (iii) Complexity through the organization levels (example of Population made up of several social layers), and (iv) Dynamic complexity of chaotic behaviour (dispersion effect, linear system) [48].

3. If and only if independence achievement meant the acknowledged ability for the city's affairs to be organized and efficiently managed independently.

4. In Cameroon, the waste management framework is not regulated by any text. Only the 1974 law reorganizing municipalities and local governments briefly reports that these municipalities and local governments are responsible for waste disposal.

5. The common and acknowledged practice by the State is collection of a household refuse collection tax and funding of waste management through the local government budget. Unfortunately, this tax is so meagre that municipalities do not have financial means necessary to provide adequate services to which urbanites have a right.

6. In total, 148 garbage bins for a population of nearly 1,500,000 inhabitants, of which 39 only have a 16 m<sup>3</sup> capacity.

7. Many observers explain Yaoundé's insalubrity through public authorities' inefficiency. This dominant speech must be put on with the sociological reading of the phenomenon. It seems that massive presence of garbage in the urban space stems from the transfer of rural cultural modes. Yaoundé's accelerated urbanization was largely due to rural-urban migrations. Given that, urbanization was mishandled and instead of having an urban environment, Yaoundé currently displays a mix landscape with a dominant rural feature [Ela, 1984]. This rural character is obvious in the city's peripherals where neo-urbanites are making use of lands following rural culture and practices. ZOA (1996) succeeded in demonstrating that space pollution caused by household refuses was linked to ritual and cultural practices relevant to rural ethnic groups. According to Nga Ndongo (2001), Yaoundé's solid waste problem is everyone's concern i.e. men, women, social groups and different communities who still bear socio-cultural models inherited from their village customs and beliefs.

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