Global Alliance Against Cholera

A conceptual design of a new paradigm for the elimination of cholera

Case study for the Democratic Republic of Congo

January 2011

TABLE OF CONTENTS

FIGURES AND TABLES

ACRONYMS

ARC	African Regional Committee
CTC	Cholera Treatment Centers
DRC	Democratic Republic of Congo
DRCPF	Democratic Republic of Congo Pooled Fund
GAAC	Global Alliance Against Cholera
GIS	Geographical Information System
MPH	Ministry of Public Health
NGO	Non Governmental Organizations
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund
VEF	Veolia Environnement Foundation
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization

INTRODUCTION

This new strategy to eliminate cholera in the Democratic Republic of Congo (DRC), and other affected countries, includes but goes far beyond the traditional emergency medical response to cholera epidemics. This proposed new paradigm will effectively eliminate cholera and other waterborne contagious diseases by analyzing, securing, and reinforcing access to potable water, health education, and effective sanitation services for at risk populations.

The new paradigm is based on two interrelated principles:

i) Enforcement of epidemiological surveillance in at risk populations, including the screening of suspected cases, through which laboratory confirmation will identify the pattern of the spread of the disease; and
ii) Designation of sanctuary zones in which the provision of potable water, focused health education and effective sanitation facilities will be assured for vulnerable areas in which the cholera epidemics are likely to emerge.

These actions will only be successful given a proper and timely transfer of technical competencies to the local health service personnel, and the launch of effective public health information campaigns about cholera contamination factors that must be understood by the “at risk” local communities.

Statistics of the World Health Organization (WHO) indicate more than 150,000 cholera cases between 2002 and 2008 (with the probability of at least the same number of unreported or misdiagnosed cases as diarrhea) in DRC. The severity of cholera epidemics in DRC establishes the country as experiencing the highest level of reported cholera cases, representing close to 15% of worldwide cases and 20% of reported deaths due to cholera during this period.

At the 57th African Regional Committee (ARC), hosted by the WHO in 2007, resolution AFR/RC57/WP/A was passed in order to insist on the responsibility of the member States to reinforce the prevention of cholera. In 2008, the Ministry of Public Health (MPH) in DRC demonstrated its concern to respect this pledge by adopting a national “Strategic Plan for the Elimination of Cholera”. This Plan is organized into 6 complementary activities to eliminate the disease from the Congolese territory by 2012:

i) Reinforcement of epidemiological surveillance;
ii) Strengthening of preventive measures in targeted health zones;
iii) Organizing health education activities for at risk communities;
iv) Providing hospital and in-home care for infected people;
v) Assuring overall coordination of the Government and Non-Governmental Organization (NGO) activities in preventing the spread of cholera once it emerges;
vi) And promoting operational research to identify and eliminate sources of transmission.

This integrated approach is incorporated in the new paradigm on three strategic levels:

i) First, assuring a full understanding of the disease and its patterns of diffusion to all health related service providers;
ii) Second, determining the engineering needed to improve access to potable water, and to establish potable water and sanitation facilities in the designated high risk zones;
iii) Third, consolidating the previous two steps into a targeted health education plan that assures a sustainable and effective answer to the prevention of cholera.

The following Procedural Guide for the implementation of the new paradigm has been prepared by members of the Veolia Environment Foundation (VEF), the Global Alliance Against Cholera (GAAC) Secretariat. It is respectfully submitted to the Advisory Council of the GAAC for its immediate consideration.

1. Epidemiology and methodology issues

1.1 Epidemiology of cholera

1.1.1 Cholera: origin and symptoms

Cholera is a bacterial infection caused by the Vibrio Cholerae bacteria (serogroups O1 and O139). It is a waterborne disease that is transmitted by contact between people and/or by consuming contaminated food and drinks. A person can be directly or indirectly contaminated by feces or vomitus of an infected individual (pathogens can remain infectious in patient feces for 7 to 14 days). About 75% of cholera infected people do not develop any symptoms; however their feces can contaminate the local environment, and therefore constitutes a major risk factor in the epidemic spread of this disease.

The main symptoms of cholera are profuse watery diarrhea and vomiting which can lead to a rapid and severe dehydration. These symptoms need rapid medical care and intravenous rehydration. The fatality rate of untreated cases can reach 30-50%.

1.1.2 Cholera: epidemic pattern

Due to the short incubation period (between two hours and five days), the epidemic pattern appears as a rapid increase in cases. It is the nature of explosive epidemic curves that characterize the classical picture of a cholera outbreak.

Knowledge of geographical and epidemiological patterns of this disease, based on retrospective analysis, is a key factor to control its spread. Outbreak detection and organizational responses must be effective and in place particularly in high risk areas. The absolute minimum in preventive services must include availability of potable water supplies, sanitation facilities to end open field defecation, and hand washing guidance and facilities. Effectively implemented water, sanitation and hygiene (WASH) programs will quickly end the intensity of the outbreak in these areas.

Cholera outbreaks remain an ever present public health concern. In a larger sense it is an accurate indicator of insufficient economic and social development in the area.

1.1.3 Surveillance and reporting

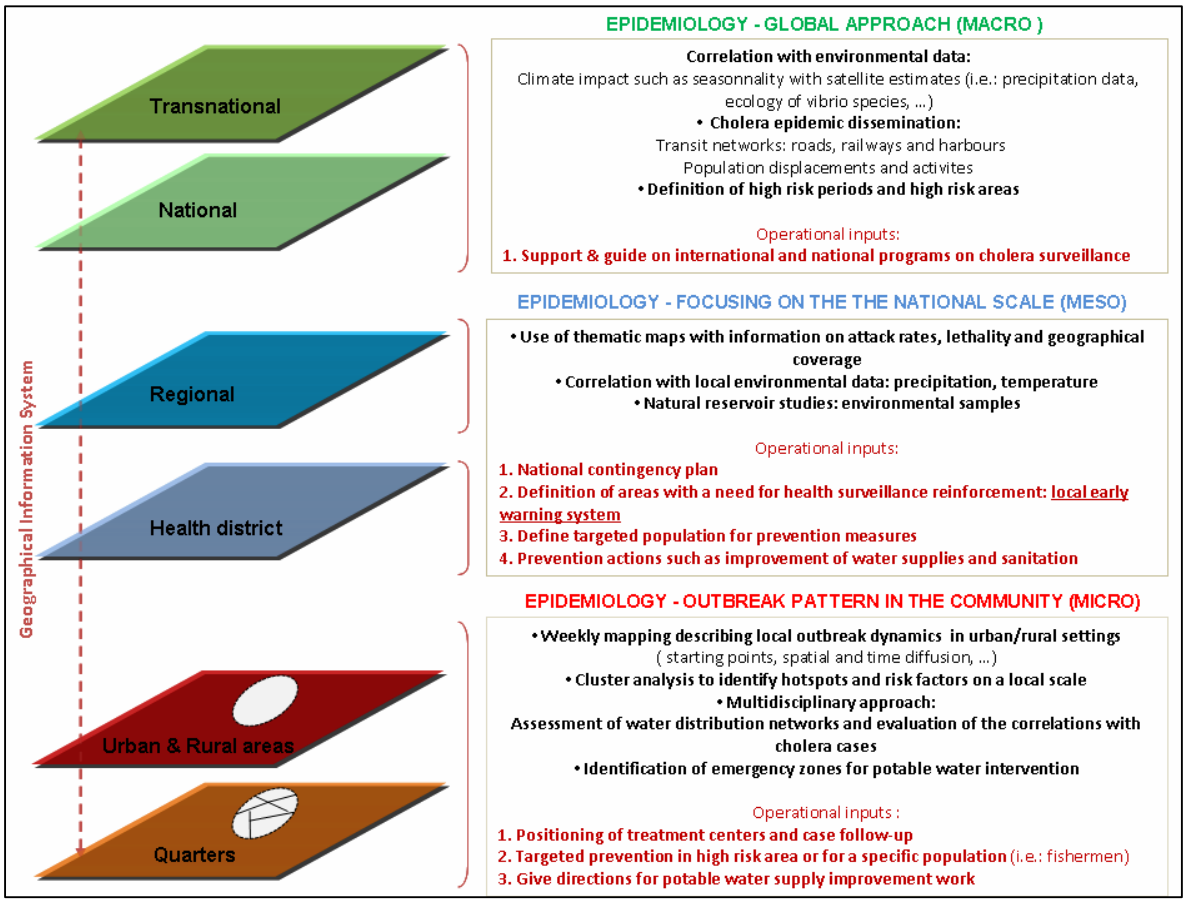
In cholera affected areas, the disease may be monitored by a health surveillance system. However, detection and evaluation of the extent of a cholera epidemic often appears to be deficient in scope and delayed in time. These realities highlight the necessity to identify high risk areas where early detection can be verified and rapid response implemented, in order to slow down and quickly stop the spread of an epidemic.

When an outbreak is suspected, rapid verification should be done by a qualified local response team that could confirm the presence of cholera using rapid diagnostic tests. In this case, a Geographical Information System (GIS) would improve the detection of the emergence of an epidemic by defining threshold characteristics of the emergence and spread of the disease and produce a clear indication of affected areas, such as specific neighborhoods of a town. These data are practical guidelines for field investigations as well as for rapid and targeted responses.

In regularly affected areas, a better comprehension of epidemic dynamics through long term data collection is clearly needed. This means a focus on the early stages of the epidemic, followed by a track of the geographical spread during the initial period and extension of outbreaks. Thus, different approaches must be combined in order to have a better picture of cholera epidemiology. The results

would then guide prevention and control activities in targeted areas, such as assurance of potable water for distribution, access to sanitation and promotion of preventive hygiene practices. A global strategy adopted for the geographical analysis of cholera determinants is illustrated in figure 1.1.3.

FIGURE 1.1.3: Framework for a comprehensive approach using Geographical Information System for cholera epidemic assessment



Source : B. Sudre, University of Franche Comté

1.2 Methodology overview

The strategy is based on modern epidemiology that uses GIS technology as a tool which is integrated within an eco-epidemiological framework. Monitoring by using GIS technology is combined with field visits to assess source(s) of exposure and transmission mode(s)[1].

The methodology relies on a top-down analysis, starting with a comprehensive trans-national level analysis, and narrowed to understanding the origin of the epidemic at a local level (neighborhood, quarter, or street).

1.2.1 The macro-epidemiology: a global approach

Cholera assessment for a given country requires several levels of understanding. The first level is based on analysis of the general context of the country, including data on elevation, environmental estimates of precipitation, temperature, national geography, operational transportation infrastructure, existing health surveillance system and general history of the country. For numerous countries, annual data on cholera at the national level can be collected on the WHO website.

A similar mapping of neighboring countries will produce an overview of cholera case and death distribution in a larger region, from which a global profile can be developed. This is of particular interest when inter-epidemic periods tend to be defined over a long period of time. A synchronization of emergence of epidemics between bordering countries should also be made as this leads to a better awareness of regional epidemiology and serves to identify the possible patterns of transnational spread of cholera outbreaks.

1.2.2 The meso-epidemiology: focus on national scale

The second level is to collect and analyze national data on cholera cases of the health zones within a large temporal window. This will provide the foundation for an initial understanding of cholera patterns in the country. There is also need for dedicated collaboration and support from the Ministry of Health whose data could be made available for comparison with other data sources to determine their level of accuracy (i.e. from NGOs). This contributes to analyzing patterns of the disease through modeling of seasonal and general trends including the dormant phase of the cholera bacillus.

This information in correlation with seasonal and environmental factors helps in determining high risk periods of epidemics that can predict the onset of cholera epidemics.

Morbidity and mortality mapping of cholera cases at a sub-national level, based on sequential maps (weekly or monthly), helps to define the different patterns of cholera epidemics: unaffected areas, temporarily affected areas and permanently affected areas. Inter-epidemic time periods (without any notified cases) are verified with the re-emergence of each cholera outbreak. The degree of endemic cholera nationwide can be determined given several profiles:

1) Long interruption periods with no reported cases contrasted with the re-emergence of cholera in a known high incidence area, and/or acknowledgment of cases determined to originate in a neighboring country;

[1] This approach was developed in a collaborative manner with various researchers from the University of Franche Comté (UMR 6249 - laboratoire CHRONO-ENVIRONNEMENT), University of Méditérranée, some NGOs such as Médecins du Monde, and the MPH of DRC.

2) Several small geographical areas reporting cholera cases (with/without epidemic profile) at the national level under a meta-stability requirement. If these hotspots are not controlled and eliminated, large epidemics can occur particularly among displaced populations or can be triggered by environmental factors (i.e. rainy season). These “residual places”, where cholera outbreaks occur, constitute the key areas for early targeted interventions.

1.2.3 The micro-epidemiology: outbreak at the community level

The third level of understanding results from the study of the areas of re-emergence/persistence of cholera outbreaks. These locations can be compared to “roots” of a larger epidemic onset where different patterns do exist: for instance, areas where cholera cases are always associated with marked seasonality increases, where an ecological correlation with one or more environmental/ anthropogenic parameter might be suspected, or areas with an absence of reported cases during an inter-epidemic period but where emergence of cholera epidemics are recurrent in a time-series descriptive analysis.

For these areas, a map of smaller health units needs to be drawn (if not available) and supplemental health data needs to be collected in the field. This provides a better understanding of smaller scales such as rural districts or neighborhoods of a city. However; for large cities, the spatial designation by health units alone is usually insufficient to obtain a clear picture of the disease dynamic. A specific GIS can in such instances be designed for a city, with the involvement of local competent authorities (health and administrative) and their representatives. During fieldwork, the city can be profiled into smaller units. This new segmenting can then be integrated in a GIS layering and the resulting map will be made available to cholera treatment centers (CTC) and other health care facilities. When an infected patient is registered in a CTC, the exact location of his/her home will be identified on the map to allow detailed studies of the site. In addition to the map, an electronic database of the same spatial units would be available to the health surveillance personnel in the community and to the CTCs.

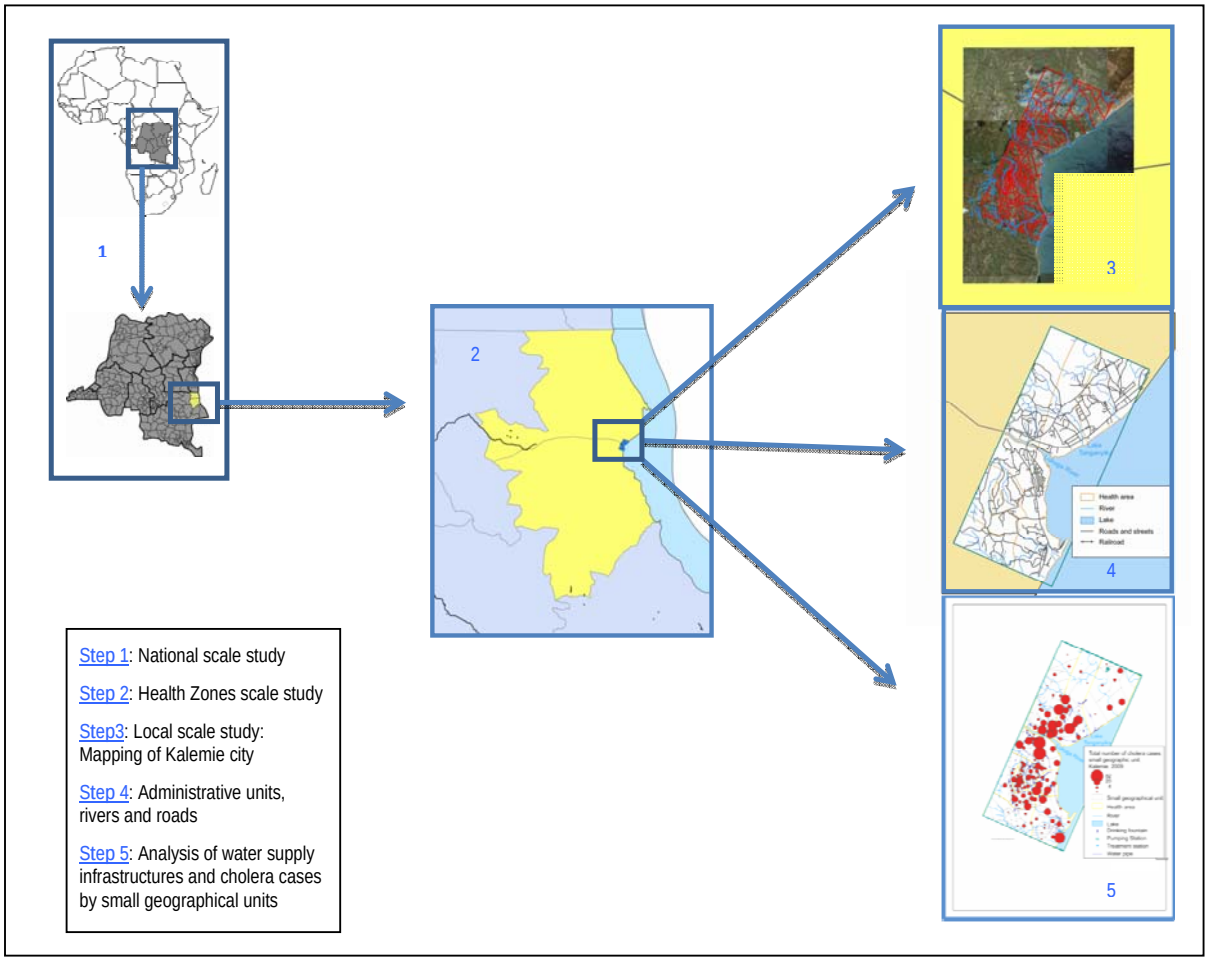
The objectives of the GIS procedure are:

1) to identify the dynamics of the source and subsequent diffusion of cholera in any community;

2) to monitor effects of preventive measures and responses during the emergency phase of the outbreaks. A practical application of these results for rapid response can be found in the counseling and orientation sessions with confirmed cholera patients for the placement of emergency water chlorination points near to their homes. In a broader context, endemic high risk areas can be identified within which to establish potable water supply infrastructure, proper sanitation systems and hygiene information and promotion before the onset of an epidemic.

This geographical modeling tool can be used in combination with a parallel assessment of the currently available potable water distribution network, water treatment plants and sewerage facilities, using the same geographical log frame. Comparison of cholera case locations with the availability or lack of water/sewer facilities for the same geographical areas will verify with great precision the specific zones for immediate intervention.

FIGURE 1.2.4: Creation of a modeling tool: step by step



Source : M. & R. Piarroux, University of Méditerranée ; Veolia Environnement Foundation

1.2.4 Monitoring of actions at local level

The "Strategic Plan for the Elimination of Cholera" highlights two important axes: the reinforcement of the activities of epidemiological surveillance and the promotion of operational research. The first point emphasizes the need for better identification of cholera cases in the public health recording system that would include all relevant patient characteristics, and **geographical information** on the patient's household location. Quick identification of patients with acute diarrhea is integrated by GIS to orient rapid response assistance to a high risk area and subsequently to monitor and analyze long-term trends of cholera cases by discrete neighborhoods. In addition, **biological confirmation** of cases is of primary interest to accurately define period(s) and place(s) of pathogen agent circulation.

In the mid-term to long term, these reinforcements of local capabilities are aimed at improving cholera surveillance and are crucial in assessing the efficiency of this integrated approach. This approach must however be flexible to allow for reorienting resources depending on a rapid change in the epidemiological picture, particularly during emergency periods, such as the sudden arrival of a population fleeing a local conflict or natural disaster.

2. Water and Sanitation engineering

Water facility infrastructure in DRC has suffered from severe damage, and lack of repair and maintenance particularly in the remote eastern regions where the increasing population of the cities has heightened the inadequacy of treatment, distribution and storage of potable water supplies.

Following the independence of the Country in 1960, and for the period beginning in 1970 to 1980, each Province was in charge of the management of the distribution of its public water supplies with varying results. The Regideso[2] was then created on a National basis and achieved a high level of performance through technical and financial support, and external loans and grants. Since 1990, funding for and the operational performance of Regideso has however declined, leading to a decrease in the potable water coverage in the urban areas, i.e. 68% in 1990, to 35% in 2006[3]. The secondary cities are also inadequately supplied with potable water, following the combined effects of an ongoing unstable and insecure environment, and the lack of maintenance, staff training and operational and investments budgets. In addition, population movements add to the currently inadequate distribution systems of potable water in peri-urban and urban areas.

Given these circumstances, water system engineering and sanitation infrastructure activities must be focused initially in high risk areas to ultimately achieve the objectives of the Government's Plan for the elimination of Cholera. Although the need to eliminate all vestiges of cholera in the targeted 7 cities in Eastern DRC is of concern, the technical recommendations in this Procedural Guide are focused on the need to identify cholera "hotspots" within the targeted cities for quick intervention. The diagnostic procedure in these instances will apply to the production, treatment, storage and distribution of the urban potable water supply networks.

The reliability and supply of electrical power will be added to the diagnostic procedure as will the urgency for determining the availability sanitation facilities and educational services to encourage their use.

2.1 Water Production: resources and stations

Potable water production requirements are based on evaluation of existing and potential resources, to determine the operational efficiencies of the treatment, pumping and distribution systems, so as to determine necessary short and long term improvements.

[2] National Water Ministry of DRC

[3] World Bank report on the Regideso in DRC, 2009

TABLE 2.1: Water production diagnosis

Actions	Description	Details
Diagnosis of the raw water resources	Testing and verification of the availability and quality of the resources	1. Analyze the quality and quantity of the raw water resources; 2. If not satisfactory, determine if an alternative water resource is available;
Diagnosis of the pumping and treatment stations	Identification of the emergency elements for the rehabilitation and possible increase of the production capacity	3. Assess the process, equipment and production capabilities of the stations; 4. Present a quantitative and qualitative analysis of the overall process; 5. Audit the maintenance personnel and the level of technical in-house capacities; 6. Rank proposed actions: from the emergency repair, rehabilitation, to the increase of water production and capacity building programs; 7. Propose a detailed cost analysis for the implementation of the recommended actions;
Additional information	Specification of the initial needs assessment	8. Microbiological and physicochemical historical data of the resources; 9. Records of the production process;
Production of support documents	Helps decision making and sharing of the information for the stakeholders	10. Detailed report of the pumping and treatment stations.

2.2 Water Distribution: the network

The analysis of the public water distribution system follows a similar procedure, which will substantiate a comprehensive assessment of items needing emergency rehabilitation, such as where extensive damage is noted for major repair, such as for an increase of water pressure and supply.

The assessment can include the computerization of the water distribution system through Epanet ®, and GIS MapInfo® which will simulate the spatial distribution of water in the city and identify both emergency and long term rehabilitation requirements for the network.

TABLE 2.2: Water distribution diagnosis

Actions	Description	Details
Diagnosis of the public water network	Presentation of a diagnosis of the network; Proposition of emergency rehabilitation requirements and possible improvements in the distribution capacity of the network	1. Assess the network (water pipes, protective equipment and storage capacities); 2. Present a qualitative and quantitative analysis of the network; 3. Audit the maintenance program and the level of technical in-house capacities; 4. Prioritize the proposed actions: including emergency and/or routine rehabilitation, increase of water distribution and/or storage and capacity building programs; 5. Propose a detailed budget for the implementation of the recommended actions;
Additional information	Specification of the initial needs assessment	6. Actions required for the implementation of recommendations (topographic meters, mapping drafting, design calculations …); 7. Statistical analysis of the available archived data (operations of maintenance, leakages, …);
Production of support documents	Helps decision making and sharing of the information for the stakeholders	8. Detailed report of the public water network; 9. Mapping of the network (technical specifications: lengths, diameters, waterworks); 10. Modeling tool for water distribution.

2.3 Power production

The analysis of the power plant is critical to the effective production and distribution of potable water in the targeted high risk areas. Power production has a direct impact on the availability of water as the water pumping stations at this time have to adjust to several power failures per day, if not longer periods of time (months). The objective is to secure adequate availability of potable water in the city, which is highly dependent on reliability of electricity.

TABLE 2.3: Power production diagnosis

Actions	Description	Details
Diagnosis of the power plant	Identification of available resources, overall production capacity and problems	1. Assess the infrastructure of the power plant, protection of engines, appropriate dimensioning; 2. Present a qualitative and quantitative analysis of the power plant; 3. Audit the maintenance program and the level of technical in-house capacities; 4. Prioritize the proposed actions including emergency and/or routine rehabilitation, increase of power distribution and capacity building programs; 5. Propose a detailed budget for the implementation of the recommended actions;
Additional information	Specification of the initial needs assessment	6. Review of the archival records of the monitoring process including power failures experience;
Emergency recommendations	Securization of the production of alternative electricity during power shortage periods	7. Determine the correct capacity of an emergency generator to supply power for sufficient minimum water requirements; 8. Several components shall be considered for the appropriate sizing of generator(s), such as: level of the ground, fuel oil supply, impacting environmental factors (sun, humidity, dust, sand), location of the generator, sound disturbance, maintenance skills, gas evacuation, associated expenses for local population, ...).

2.4 Sanitation

The prevention of health hazards due to open field defecation and improper handling of food and drinks are critical to reduce risk of cholera transmission. The initiatives targeting the improvement of sanitation are similarly important to that of access to potable water in the long term prevention of water-borne epidemics. This is particularly true in urban settings where rapid increase of the population has not been supported with toilets and hand washing facilities, and the educational resources needed to encourage their use. Sanitation is a global concept encompassing different themes all of which must be respected.

- First, an analysis of the environment will identify obvious factors that result in cholera disease transmission. In DRC, it is common for the people to use rivers as a source of potable water. Rivers however become cholera contaminated when human feces are carried into them, especially during the rainy seasons. This is one example of the links to waterborne disease outbreaks.

- Second, water and food sanitation requires safe handling, storage and delivery of food and water to a given population. The transmission of cholera is also attributed to the contaminated hands of food preparers and servers, and to the lack of potable water, particularly within market places and public transportation centers.

- Third, on-site sanitation includes the collection and treatment of human waste (i.e. pit latrines or septic tank disposal). A program designed to improve sanitation infrastructure must be based on a realistic assessment of the current situation in order to define the required remediation steps. The use of GIS could also be employed in topographic studies to determine the risk assessment of latrine flooding during the rainy season.

- Finally basic sanitation deals with the management of human feces at the household level. This point is directly associated with cultural habits and personal/cultural hygiene practices. Thus, hygiene promotion and dedicated educational programs at the individual, family and community levels are the principle requirements to encourage essential behavioral changes to prevent disease contamination.

Similar to the potable water and energy diagnosis, the sanitation evaluation is incorporated into a comprehensive activity schedule.

From previous epidemiological studies in DRC, several characteristics have already been identified and are included in the suggested integrated approach. For example:

- The specific urban areas of Kalemie and Uvira reflected in this “Conceptual Design” present the reality of significant heterogeneity in their populations. This has resulted in high density areas, in a noticeable gap between « bid and ask » when the population is faced with the need to pay for establishing a connection to a public sewer and/or to a septic tank system. Resolution of this issue will require extensive community education to support the need for infrastructure investments for solid waste and waste water collection and treatment that would ultimately be borne by the residents and the city administration, but which could be initially provided by aid agency contributions.

- Other environmental considerations:

    - The tropical climate with heavy rainy seasons that result in land erosion, can lead to the flooding of traditional latrine pits resulting in a high risk of dispersion of biological

contaminants. During flooding, raw sewage drains to nearby rivers, which leads to temporary contamination of the shallow water areas used by local inhabitants.

- The cholera hotspots in Kalemie and Uvira are located in riparian environments where the use of shallow water for home drinking supplies is common (i.e Lukuga River in Kalemie). In this case a short environmental cycle of cholera transmission can lead to outbreaks and maintain the circulation of the pathogen agent in the local population. Improved sanitation will diminish or eliminate environmental contamination by human fecal matter especially if associated with a secured fecal waste and disposal procedure.

- The anthropologic factors related to the perception and use of sanitation by the population at large is essential to a sustainable cholera prevention program. Household behavioral acceptance of correct sanitation procedures must be encouraged through health education and demonstration activities and availability of supplies.

3. The integrated approach: illustrations

3.1 General presentation

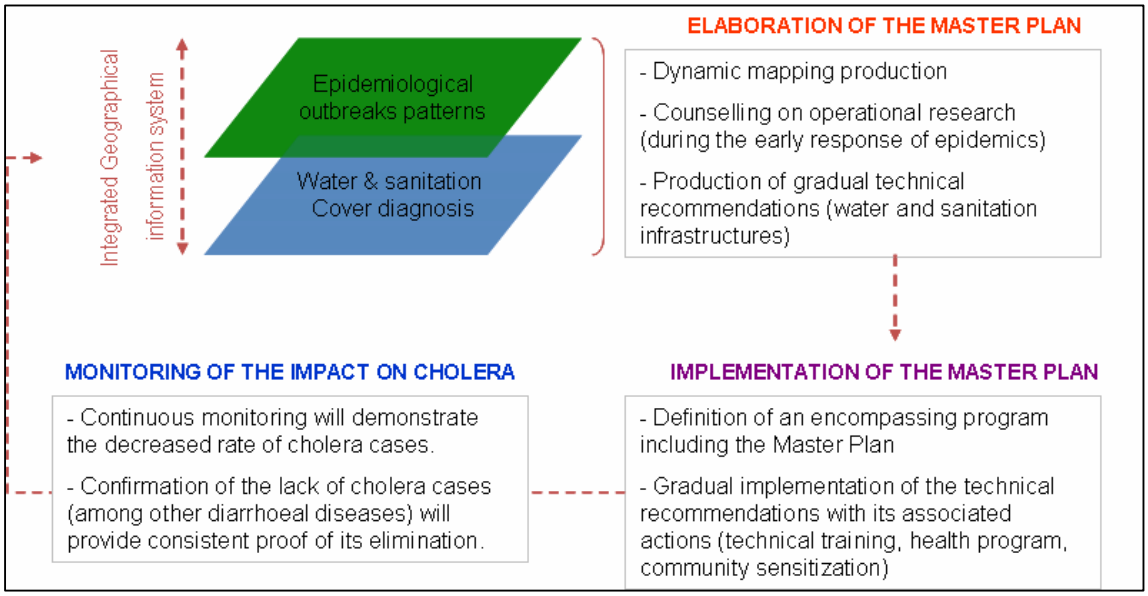
The methodology is qualified as integrated as it presents interlinked actions of epidemiological studies and WASH interventions.

The methodology is based on a threefold approach:

- First, the epidemiological studies enable a deep understanding of cholera dynamics (onset transmission and control);
- Second, interventions are focused on potable water supply and adequate sanitation for specific hotspots to end their threat. This is supported by the associated action of the community health specialists on essential personal behavioral change, in addition to technical training on the maintenance of equipment including emergency use of point-of-use water disinfection chemicals, all of which is needed, to secure the long term elimination of cholera;
- And third, the results of the actions of WASH promotion are monitored to verify the actual ending of the epidemics.

Cooperation among all of the relevant anti-cholera agencies will lead to the elaboration of an integrated Master Plan based on an epidemiological analysis of a given geographical zone from which engineering, provisioning and educational recommendations will have been identified and prioritized.

FIGURE 3.1: The methodology of the integrated approach for the elimination of cholera



Source : Veolia Environnement Foundation

Our integrated Master Plan follows 7 sequential steps:

1) Initial discussion with local health service personnel involved in the high risk zone;

2) Preliminary mission to assess the epidemiological situation in the zone;

3) Water and sanitation assessment missions are conducted in close cooperation with the local authorities;

4) Additional studies (topographic, epidemiologic data, civil works and equipment pricing…);

5) Production of maps, procedural plans and funding requirements;

6) Submission of the different stages of implementation of the proposed Master Plan (by the participants involved in its development) to the local authorities;

7) Epidemiological monitoring of the impact on these activities on the reduction of cholera cases.

Step 6 requires different levels of implementation from emergencies to long term sustainable interventions:

1) Initial emergency actions are essential in the predetermined hotspots based on the epidemiological studies;

2) Securing and rehabilitation of the overall potable water distribution system would be a second step;

3) Installing new pipe segments, and/or increasing potable water treatment, production and/or storage capacities would be a long term solution to increasing the quantity and quality of the distributed water, especially in high risk areas for cholera.

The implementation period that is required for the Master Plan will need to be divided into different stages of action depending on the availability of funding.

3.2 Stakeholders: an operational multi-partnership

The methodology is applied through operational partnerships involving a wide range of participants, with the end-beneficiaries placed at the center of concern. The community targeted by the program has to be considered as a whole, as any action to eliminate cholera by preventing the contamination of at-risk populations depends upon the cooperation of the entire community. The prevention process clearly benefits the broader population.

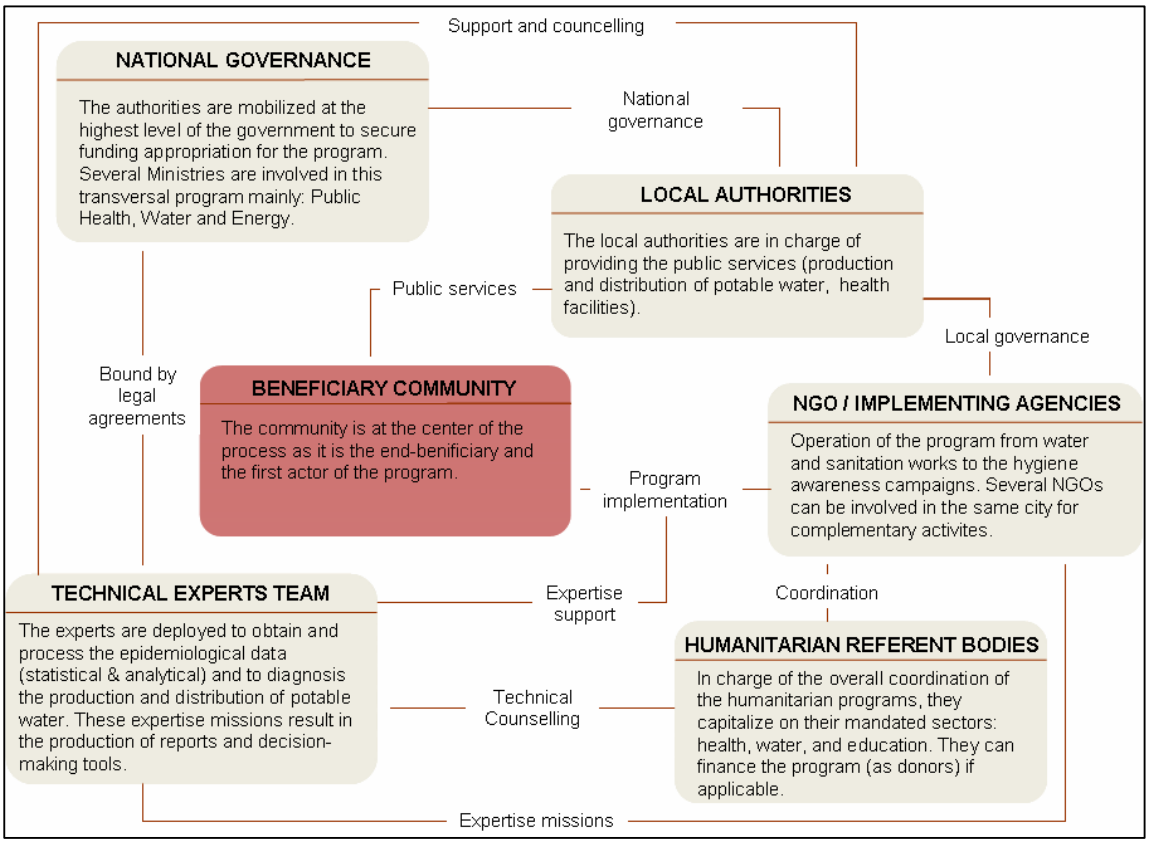
Involving the community also includes encouraging their concern for adequate treatment facilities, public health centers where data are gathered, and health education services to encourage essential behavioral changes.

The technical experts (epidemiological, educators and water and sanitation engineers) provide their assessments to the local NGOs in cooperation with the local authorities. Several missions have to be scheduled to develop the Master Plan for any given region or high risk zone in coordination with the implementing NGOs. The humanitarian organizations that are in charge of specific clusters (UNICEF[4] for WASH, WHO for Health) must be involved to assure their coordination of the new services with their programs. This will result in the structuring of a more effective overall cost/benefit relationship that could lead to additional funding to support essential NGO involvement.

[4] United Nation Children's Fund

The Veolia Environment Foundation expert team that has been developing this Conceptual Design for a Master Plan during the past three years, has initiated partnership agreements with the relevant Congolese Government ministries and several NGOs, as indicated in figure 3.2.

FIGURE 3.2: Operational inter-relations



Source : Veolia Environnement Foundation

3.3 Presentation of case studies

3.3.1 Definition of the studied zones

The DRC is one of the most severely cholera affected countries in the Great Lakes region. Since the late 1990's cholera cases have been increasing in the Great Lakes region, with the DRC reporting 31,150 cases (88 % of the total number of cases within the Great Lakes region) according to WHO weekly epidemiological report (2009).

The 7 urban areas of direct concern to the Global Alliance Against Cholera have been defined by the Ministry of Health from retrospective analyses of notified cases of cholera from 2002 to 2008. High and

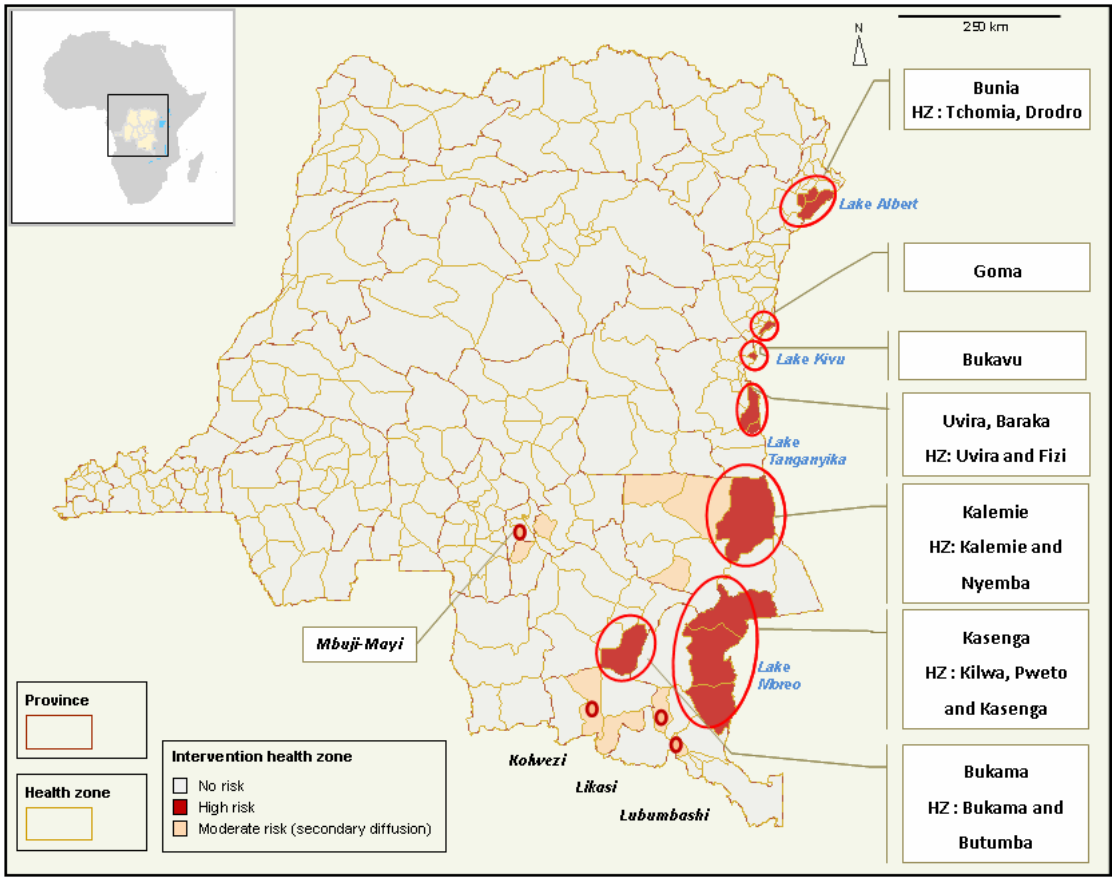
moderate risk areas were identified using field assessments and modeling[5] [6]. Based on these results, a set of priority zones have been defined as high risk areas where cholera outbreaks re-emerge or persist in inter-epidemic periods. These zones have been considered as “the sanctuary areas” of the disease and are generally city and village areas bordering lakes or flood prone areas, and areas defined as having limited access to potable water and appropriate sanitation. Generally, these high risk zones are connected to and from riparian areas by roads, railroads and/or rivers, which increases the risk of transfer of cholera by contaminated individuals.

In these high risk areas, immediate access to potable water constitutes the principal action required to diminish the risk of cholera outbreaks. In parallel, epidemiological surveillance must be able to detect and verify suspected cholera cases without any delay at the start of an outbreak and to monitor the results of the implemented programs. Health promotion that leads to acceptance by the high risk population of improved personal hygiene must also be included to complete this multi-sectoral approach.

[5] Cholera epidemics, war and disasters around Goma and Lake Kivu: an eight-year survey. D. Bompangue, P. Giraudoux, M. Piarroux, G. Mutombo, R. Shamavu, B. Sudre, A. Mutombo, V. Mondonge, R. Piarroux. PLoS Negl Trop Dis. 2009;3(5):e436. Epub 2009 May 19.

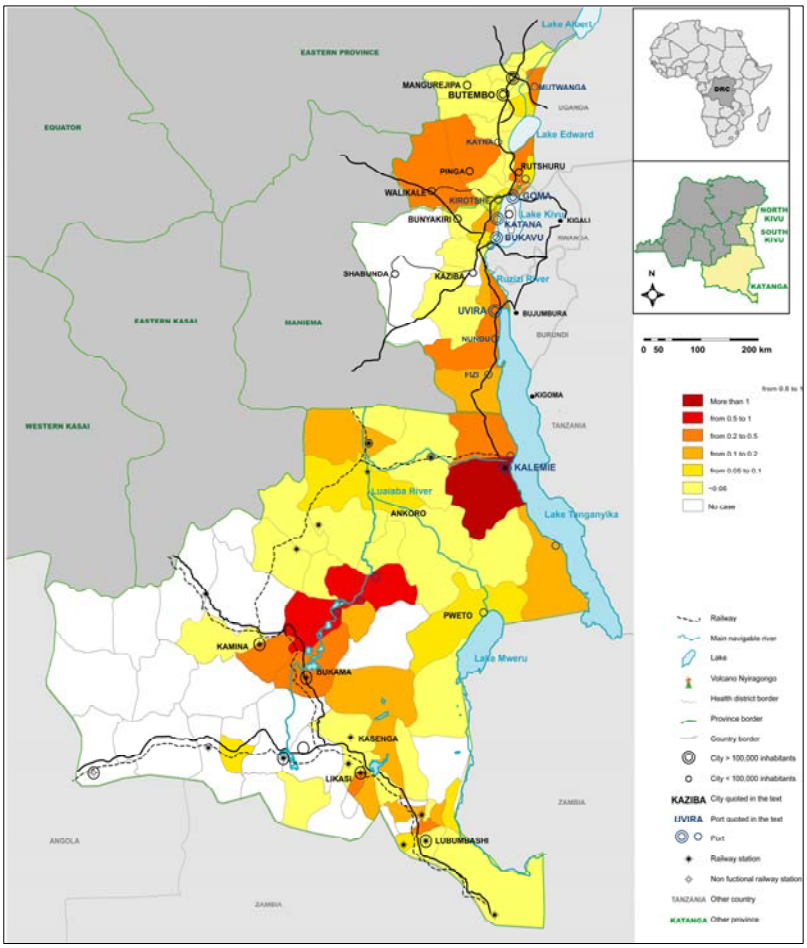
[6] Lakes as source of cholera outbreaks, Democratic Republic of Congo. D. Bompangue, P. Giraudoux, P. Handschumacher, M. Piarroux, B. Sudre, M. Ekwanzala, I. Kebela, R. Piarroux. Emerg Infect Dis. 2008 May;14(5):798-800.

FIGURE 3.3.1 (a): 7 zones of intervention determined as reservoirs for cholera epidemics in DRC



Source : D. Bompangue (University of Kinshasa), R. Piarroux (University of Méditerranée) B. Sudre (University of Franche Comté) *et al.*

Figure 3.3.1 (b): Incidence rate of cholera cases in Province of Katanga, North Kivu and South Kivu between 2002 and 2005

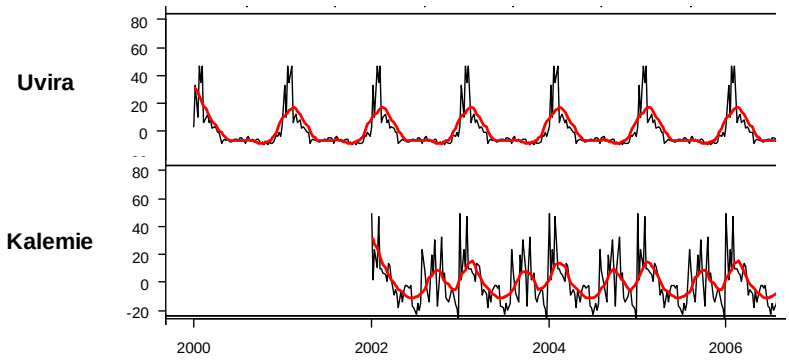


Source : R. Piarroux, University of Méditerranée

Based on the data collected between 2002 and 2008, the incidence of cholera as shown in figure 3.3.1 (b) provides an overview of the most affected health districts, where further analyses in the indicated high risk areas must be carried out.

Figure 3.3.1 (c) indicates the seasonality of high risk for the two cities of Kalemie (Katanga Province) and Uvira (South Kivu Province) within which a quick cholera response must be anticipated and prepared. In this example, Uvira's cholera incidence curve follows a single peak mode whereas during the same period, Kalemie presents a double peak risk mode. These two cities present dissimilar cholera risk periods which need further epidemiological investigation.

Figure 3.3.1 (c): Example of seasonal decomposition of times-series of cholera cases



Example of seasonal decomposition of times-series of cholera cases:

The red curve represents the seasonality amplitude of non-parametric decomposition of times-series (c.f methods "Lakes as Source of Cholera Outbreaks, Democratic Republic of Congo" in Emerging Infectious Diseases journal -2008).

Source : R. Piarroux, University of Méditerranée

These health districts are spread across a large geographical area and do not present homogeneous epidemiological patterns.

The following is an illustration of the approach focused on two urban areas bordering Lake Tanganyika: the cities of Kalemie and Uvira, where the Conceptual Design of cholera elimination programs, involving micro-epidemiological, engineering and community health practices are currently being implemented.

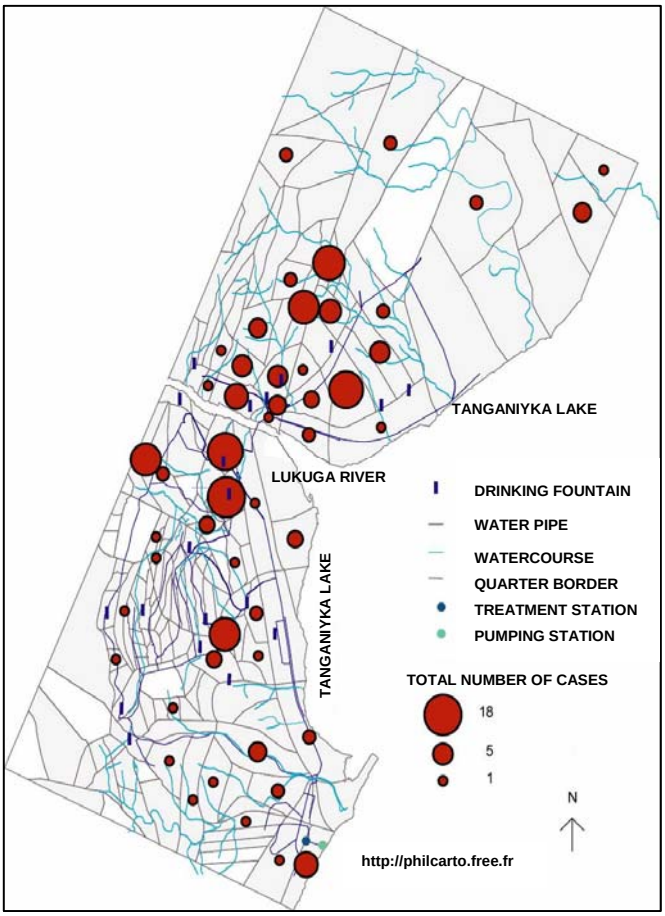
3.3.2. Case study: Kalemie

Epidemiological studies have verified that cities bordering the Great Lakes located in eastern DRC are sources of cholera outbreaks, among them; Kalemie is an example of the persistence and repeated emergence of cholera epidemics.

The water supply infrastructure established in 1954 in the city has not properly functioned for many years as a result of the lack of replacement parts, routine maintenance, and professionally trained, supervised and paid staff.

Following the methodology detailed in part 1 and 2, a GIS program integrating both the cholera clusters and the mapping of the water supply in the city has been developed with close cooperation of the local authorities. It is important to specify that the preliminary studies were associated with capacity building activities, such as training of local health service personnel to conduct GIS surveys, maintenance training activities following the donation of relevant equipment, and the development of computer-assisted programs for the epidemiological surveillance staff.

Figure 3.3.2 (a): Example of the application of Geographic Information System to identify the relationship of cholera cases and water supply



Source: D. Bompangue, University of Kinshasa; R. Piarroux, University of Méditerranée

Determination of geographical origin of cholera cases and (household or source of water) is currently underway in collaboration with local health authorities and NGOs (Solidarités International).

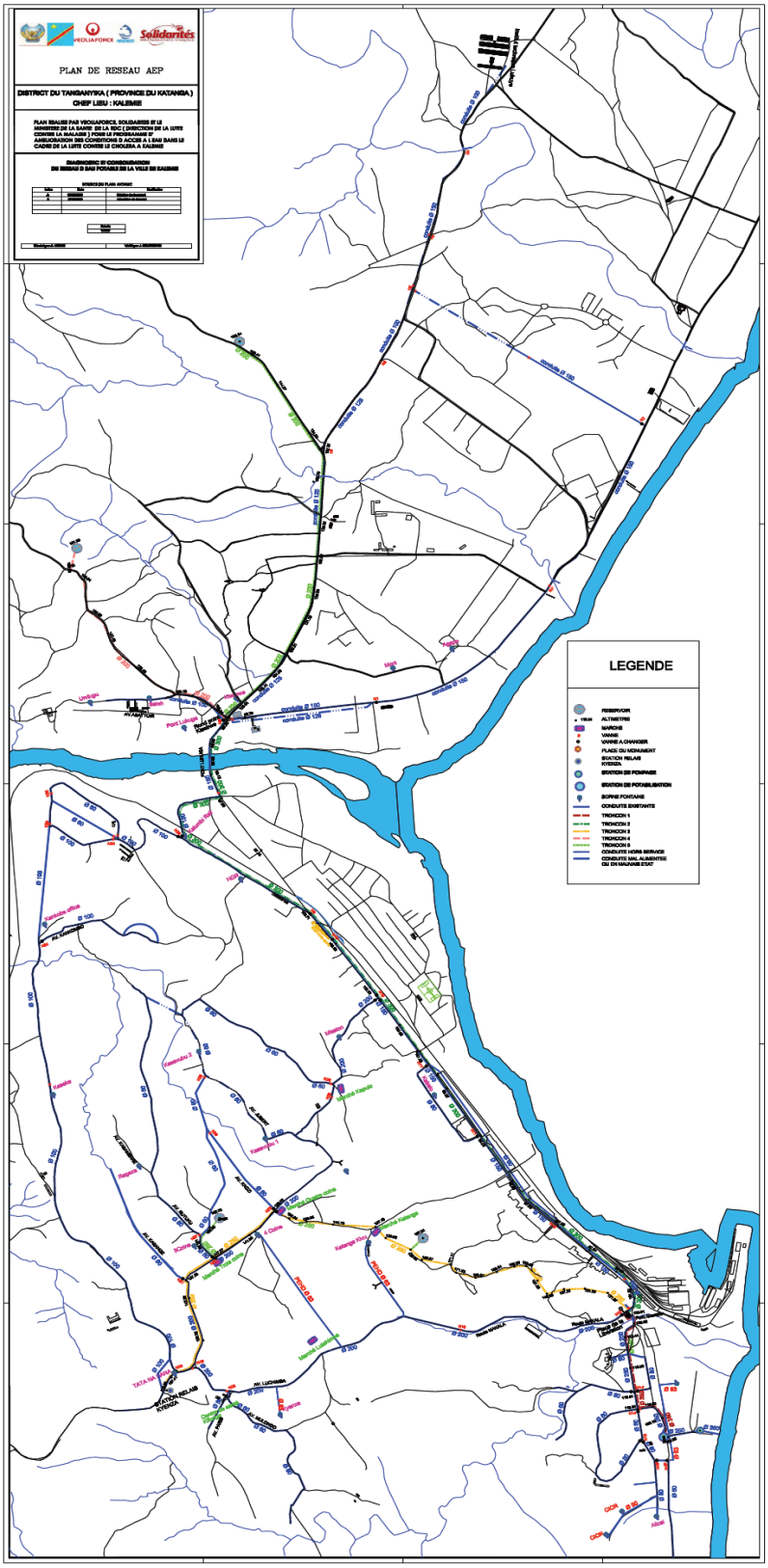
Figure 3.3.2 (a) shows the heterogeneity of the geographical distribution of cholera cases in Kalemie. Clusters of cases located near the Lukuga River match the fact of inadequate water distribution infrastructure in that given zone. Field visits confirmed it as a high risk area for cholera transmission, as the population obtains its drinking water from potentially contaminated shallow river and lake sources. Thus, the GIS exercise emphasizes the need to focus on remediation efforts in these epidemic prone areas.

In Kalemie, the first level of emergency response has been completed with replacement of pipelines in some areas of the city's water distribution network, to enable better services to begin when repairs are made on other specific parts.

In June 2010, the second phase of activity financed by a Pooled Fund[7] grant, in which the NGO Solidarités International participated, began with further technical improvements including 3506 meters of new water pipe and one water tank (500m³). These will provide potable water to the southern part of the city where extensive erosion of the ground has resulted in leakage problems which endanger the continuity of its water distribution.

[7] The pool fund is a mechanism established in 2006 for humanitarian activities in the DRC. The Democratic Republic of the Congo Pooled Fund (DRCPF) is administrated by the UNDP.

Figure 3.3.2 (b): Master Plan extract: projected enhanced water supply for the City of Kalemie



Source: Veoliaforce, Solidarités International, Ministry of Health of DRC

The program of Solidarités International is consistent with the comprehensive approach to the elimination of cholera as its technical intervention is combined with a public health awareness program securing both the understanding and the endorsement of the population for cholera avoidance activities.

The third phase of their activity will be to replace and increase the size of the primary pipes from the pumping station to increase the volume of water distribution in the northern part of the city. This will be supplemented by installation of additional water tanks to provide extended periods of water availability even with frequent power shortages in the city (figure 3.3.2 (b)). Additional partnerships and funding are being sought to implement this final step in securing effective potable water distribution.

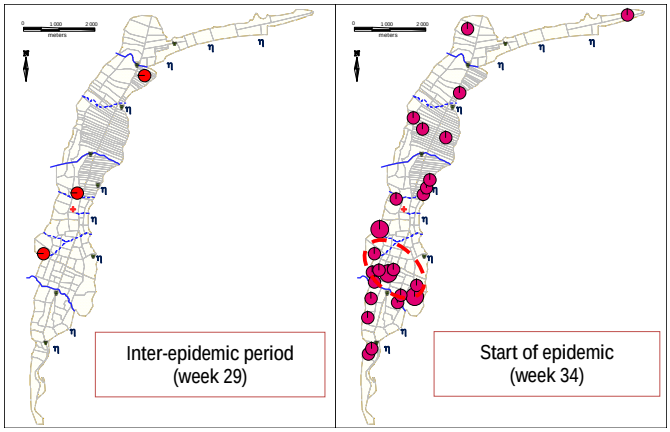
The local epidemiological follow-up program is essential in monitoring these interventions. This activity is included in the long-term strategy of reinforcement of local capacity in the field of health surveillance in collaboration with NGOs and government agencies working in health and WASH sectors.

3.3.3. Case study: Uvira

In Uvira city, the epidemiological situation is different from that of Kalemie and calls for a different response to the existing water supply characteristics. Comparing the cholera outbreak dynamics in this community (figure 3.3.3 (a)) to the modeling of the global coverage of water supply (figure 3.3.3 (b)), a clear relationship is made between water access and cholera cases. The percentage of cases recorded in the areas with little or no access to potable water supply is higher compared to areas with reasonable access to clean water. By superimposing the two layers, the cartography analysis demonstrates the importance of a global increase of potable water availability (through the increase of water distribution to the larger community), rather than targeted water improvements in localized zones as it is the case in Kalemie.

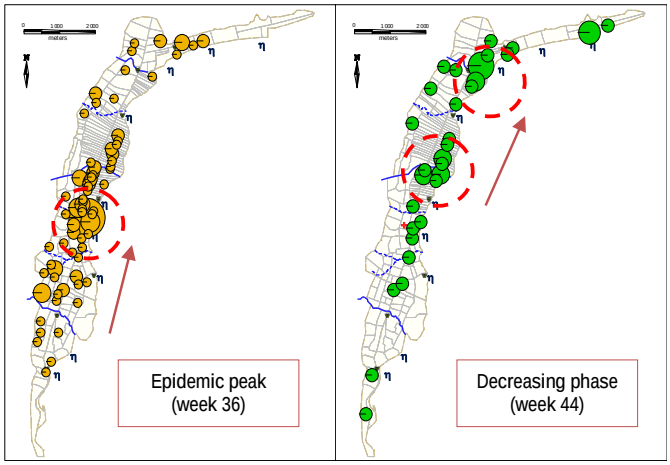
In addition to the recommended global water supply increase for this city, further activities are suggested including: the definition of the epidemics threshold in accordance with their geographic clustering, and providing technical support to the agencies in charge of supplemental chlorination activities that are necessary responses to the rapid control of cholera outbreaks otherwise without access to potable water.

Figure 3.3.3 (a): Cartography of Uvira town (circa 150 000 inhabitants) and weekly distribution pattern of cholera during the 2009 outbreak.



Source: B. Sudre (University of Franche Comté), P-Y. Oger (Consultant, Veolia Environnement Foundation) *et al.*

The above figure illustrates the geographical distribution of cholera cases at different time-points. The start of an outbreak corresponds to a cluster of cases located near the Kabindula River and markets. In this place there is a lack of hygiene, potable water and appropriate sanitation, which together increases susceptibility to water borne diseases including cholera.



Source: B. Sudre (University of Franche Comté), P-Y. Oger (Consultant, Veolia Environnement Foundation) *et al.*

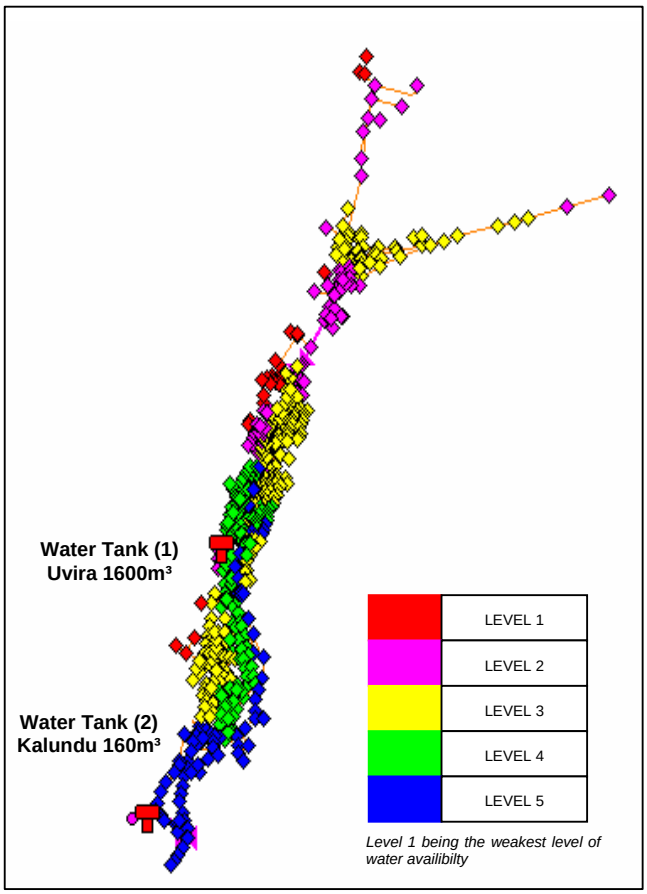
The grey cuttings are called ***spatial units****, focusing on the street level. They help in mapping a detailed geographical distribution.*

The illustrations show that the clusters move towards the northern part of the town between week 36 and 44.

The weekly mapping of cholera cases that is obtained from this monitoring tool provides data for a rapid response in the case of an outbreak, such as the choice of supplemental chlorination points where the cholera clusters are mostly concentrated.

The geographic distribution of cholera clusters is not homogenous. Figure 3.3.3 (b) below illustrates the availability of water in the public network in which the level of distribution is dependent on both its proximity to the water tanks and the difference in altitude of the underground pipes, where water flow is dependent on gravity based distribution in the network. Areas benefiting from adequate piped potable water are demonstrably less vulnerable to cholera epidemics. However, it is important to observe that most of the areas with an average level of potable water availability still report some cholera cases. This shows that there is a large diffusion of the cholera bacillus throughout the city and emphasizes the necessity of the global increase of potable water distribution as well as on sanitation and health education activities.

Figure 3.3.3 (b): Example of water availability modeled by Epanet in Uvira



Source: K. Ratsavong, Water network specialist, Veolia Environnement Foundation

The recommended action is focused on an overall increase of the production and distribution of drinking water, which will be implemented in Uvira by the Regideso. It will include improvements to the pumping station and an increase of flexibility in the drinking water network.

If the emergency recommendations are followed, the production of water should rise from 3500m³/day to 5720m³/day, i.e. a 64% total increase of water distribution through the city reaching the zones where vulnerability to cholera is the highest.

SUMMARY

The previous two illustrations emphasize i) the fact that it is essential to understand the epidemiology of cholera at different times and places as this will have a great impact on operational decisions to eliminate cholera; ii) the importance of available potable water in sufficient quantity for the population; iii) the importance of relevant health education and motivation programs; and iv) the importance of indoor and community toilet and hand washing facilities.

Each step provides complementary information that together creates a global picture of cholera epidemiology in a given country and area. The relevant operational research, based on knowledge of the disease, can only be done by involving researchers, NGOs, state and national ministries — and their local offices — at a global and community level. The benefit from the integration of these resources and the involvement of the targeted communities is vital to the success of this approach.

In targeting the sources of cholera epidemics using a large retrospective database, it is possible to define high risk zones of case origination where the onset of outbreaks is predictable. In addition, prospective surveillance is an efficient tool to monitor the impact of local interventions. By focusing on small areas where precise geographical studies and environmental assessment can be done, information and recommendations will be generated for local authorities and NGOs involved in the implementation and coordination of health, education, water and sanitation sector responses.

A comprehensive approach to quickly ending cholera epidemics must be based on a precise understanding of its dynamics. The only sustainable methodology for action is one that is complementary and simultaneous in its implementation. This alone will guarantee the desired long term objective of the elimination of cholera .Once the most vulnerable water and sanitation infrastructures are adequately secured, and the population sufficiently informed about the associated risks of water borne diseases, activities offering technical capacity building for local authorities will establish a positive climate for cooperation between NGOs, international aid agencies and DRC Government authorities.

This Conceptual Design is proposed as an evidence-based strategy to orient field, central authority and international agencies in their response to the control and eventual elimination of cholera in the DRC and in other countries facing the same situation.