The water supply situation of two major towns of Eastern Congo (Democratic Republic of Congo)

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Introduction

The Democratic Republic of Congo (RDC) is one of the largest countries in Africa with a total area of more than 2 million of Km2. It is characterized by a variety of climatic regions, with subtropical savannah areas in the north and in the south and a vast equatorial rain forest area within the limits of the Congo river basin. To the east, along the border with Uganda, Rwanda and Burundi, on the western shoulder of the great central African rift valley, several high mountains overlook the great lakes regions, with, from north to south, lake Albert, lake Edouard, lake Kivu and lake Tanganika. On the eastern shoulders of the rift, two volcanos of the Virunga chain are still active, the Nyragongo and the Nyamarugira.

From the mountains located on the western shoulder of the great lakes, the topography gradually decreases toward the huge Congo basin, mainly covered by a dense and quasi-inaccessible rain forest, which collects and drains the water of a huge number of streams and rivers into the 2nd largest river of the world, the river Congo.

Political background

This huge country has been ruled for about 30 years by Mobutu Sese Seko, with an unique policy, the "mobutism, "a dictatorial "cleptocraty", which brought this extremely rich country, at least in terms of underground resources, to bankruptcy. To survive its population has developed a quite sophisticated "art of living", based on self-help and informal approaches to replace the quasi-inexistent administration.

In the late 90's the decline of Mobutu has been accelerated by the Rwandan crisis. The whole area underwent a turmoil following the Rwandan genocide of 1994, which ended in 1996 with the first liberation war, which brought Laurent Désiré Kabila to power in Kinshasa.

This period was followed by several internal and international conflicts. In 1998, the second "rectification" war led to the division of the country into two main different areas:

- an area under control of the government of Kinshasa, mainly the west and south-west, with some support from the Zimbabwean and Angolan governments

- an area controlled by two different rebel movements, mainly the north and the east,

the Rassemblement Congolais pour la Démocratie (RCD), backed by the Rwandan, controlling part of the Katanga, Kasai Oriental et Occidental, Orientale, Nord Kivu and most of the Maniema, and South Kivu provinces and the Front pour la Libération du Congo (FLC), Ugandan–backed, which controls most of the Equatorial province and part of the Oriental one.

On top of this quasi-international conflict, several internal conflicts between the "exported" ex-combatants of the Rwandan conflict (Interhamwe/ex FAR (Forces Armées Rwandaises) and the ruling movements and between some groups of ethnical origin are still active (the Banyamulenge and the Mayi-Mayi movement in south-Kivu, the Hema-Lendu in north-Kivu).

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[1] Geneva Foundation, Independent consultant, ICRC assignment from 20.10.01 to 20.12.01.
[2] Engineers assigned to different locations in RCD on behalf of the International Committee of the Red Cross.

All these conflicts have made the situation of the region quite complex. The extremely poor security situation has led to a disastrous economic situation, in the verge to collapse.

The situation of the rebel controlled areas (RDC and FLC) has dramatically worsened since the "rectification war" when the major routes of communication, the Congo river and the railway connecting Lubumbashi to Kisangani were cut off, isolating them almost completely from any access, except from the aerial communication.

The reconciliation peace process has brought some stability since 2003, mainly in the former governmental controlled areas, leaving the eastern Congo in a relatively calm situation.

Consequences

The impossibility to exchange goods with the normal markets has created huge economic problems in these areas. Even if people have learnt to survive in a sort of subsistence economy during the Mobutu era, their daily live has become more difficult, despite the richness of the soil (e.g., timber, coltan, diamonds, gold, cobalt, tin, uranium, cadmium, zinc, manganese, germanium, bauxite, iron ore, hydropower, etc.), and the extension of the fertile soil. These resources are presently only traditionally exploited and the revenues have been used in part to finance the conflict and the cost of the involvement of the foreign allies. The few existing industries still active (textiles, medical, brewery and sodas, soap) are presently working at a maximum of 10 % of their capacity and have to stop once a while.

Most of the infrastructures, built during the colonial period, are in critical state after 30 years of "Mobutism" during which almost any investment in public works was used to feed corruption and to gain political advantage, but also because of the systematic looting that regularly followed conflicts and periods of political instability, and, to a lesser extent, of the direct and indirect damages due to the different wars. In many cases, public infrastructures like water treatment stations or electric hydro-power plants are still functioning thanks to the technical skills, competence and ingenuity of the Congolese engineers and technicians.

General problems affecting the utilities

The distribution of water in RDC has been, since its creation, under the responsibility of the REGIDESO[3], a para-state company which has its headquarters in Kinshasa. All the management, training, any new developments, the promotion of engineers to specific positions, were decided in Kinshasa, where all the revenues of the different REGIDESOs were centralized and affected to the different projects. There was always a strong corporate link among all the staff and the company remained, together with the SNEL (electricity) and may be a few other, one of the "best" managed company during all the "Mobutism" era. Even during the recent events the relationships between the different managers and the headquarters have remained strong, whenever possible.

The major problems affecting the REGIDESO are in direct relation with the economic decline due to the recent hostilities. They can be summarized as:

- decrease of the collection rate of the domestic customers
- decrease of the industrial activity with consequent decrease of the water consumption of the major consumers, reaching now level close to 10% of those before the war
- impossibility to purchase the chemicals necessary for the treatment
- lack of spare parts and tools to carry out current repairs and maintenance of the network
- increased delays in the payment of the employees, up to a minimum of 2 months to 9 months depending on categories
- poor possibility to carry out repairs on damage due to the recent wars
- poor recovery of bills from the governmental consumers and impossibility to pay those of other public utilities providing services, like those due to the SNEL (Service national d'électricité).
- The important variation of the exchange rate against the US $.

[3] From French Régie des Eaux equivalent to Water Board .

Not all the REGIDESO are affected in some way. Some, located in areas not supplied by electricity or where the electricity is produced by thermal generators, have stopped to produce water since a long time or are producing and distributing water only during a few hours a day. The supply of diesel has been dramatically affected by the different wars and the blockade of the main communication system, the rivers and, to some extent, the railway, has caused the complete stop of several stations. Many projects aimed to improve the water supply of large towns, like Kindu, had also to be stopped and were not resumed.

In the following we will describe how two of these towns have managed to maintain a minimum access to water. The case the towns of Kisangani and Goma will be described relatively in detail. Others, like Uvira and Kalémie will only quoted for because of their specific situation.

The town of Kisangani

The town of Kisangani is completely cut off from its normal supply ways since the “rectification war” and can only be supplied by air. Once a while, a few trucks manage to reach the town, but their journey may take months. Any regular supply from the river Congo has stopped either from Kinshasa or from Lubumbashi through Kindu and Ubundu, by railway and by boat.

The town is supplied by two stations. The most important one, located on the banks of the river Tshopo, close to the hydropower station, is supplying the right bank of the town. The other, located on the left bank, is distributing water into a smaller network supplying an estimated number of 40-50’000 people. Figure 1 shows a general map of the town with the location of the two plants and the primary network grid.

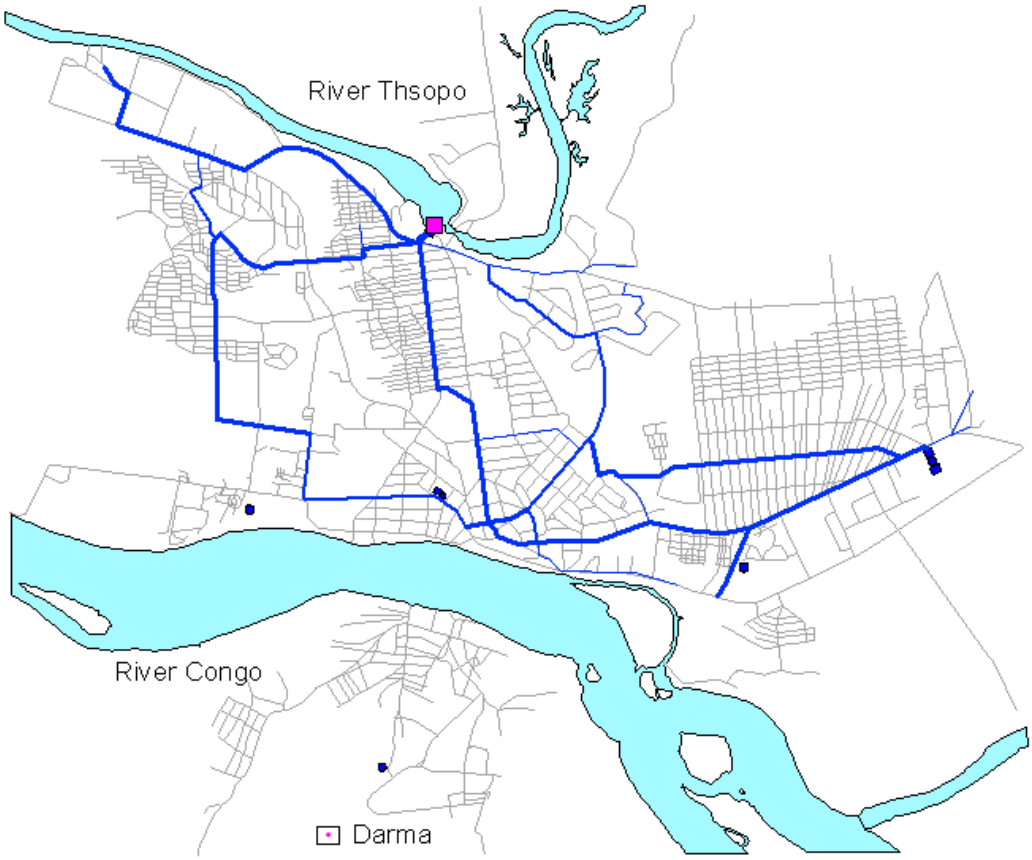


Figure 1 Kisangani Map of the town, of the road grid and location of the 2 water treatment stations, the primary network grid and the main storage reservoirs.

The main station, was in quite good condition, but has been affected by the last war and by the recent hostilities between the troops located in the town and backed by different foreign countries. The damage, affecting the supply of electricity from the nearby hydropower station, was not too important and could be partially fixed in a few days, with quite brilliant makeshift solutions. But the leakage of the special isolation oil from one of the transformers, damaged by stray bullets, may had important environmental effects, due to the persistence of the specific chemicals in the environment and particularly in the sediments, even if the high flow rate of the Tshopo may have reduced this threat. Damage was considered collateral, due to the specific location of the premises, which were located close to the strategic bridge over the river Tshopo, connecting the town to the northern areas of the province, under control of one faction. Window glasses have been quite extensively broken and were in need to be replaced.

Figure 2 High lift pumps of the new Tshopo treatment station

Daily production

Figures of the daily production were available at the station as well as many other parameters collected in a well-managed utility. REGIDESO standard reports are compiled every month. Trends can be observed but they may represent normal seasonal variations and only daily statistics do allow recognizing the possible reasons for a decrease of the production. Fortunately it was possible to get this information from the daily records, kept according to the above mentioned standard procedures. The following graph gives the daily production of the Tshopo treatment station from the 1st of January to mid-November 2000. Two main events can be immediately recognized: the first war and the second war of Kisangani, when the production was completely stopped for 3 days and 6 days respectively. From a mean amount close to 12'000 m3 / day produced during the first 6 months of the year, the production went up to 17'000 m3/day in July and finally remained fairly constant during the last 4 following months, close to 15'000 m3/day. Peaks in the production have their own explanation: the 20'000 m3/day peak in March is apparently reflecting oriented pressure by the authorities, asking the REGIDESO and SNEL managers to produce more. But the pace was not sustainable in such a difficult context and the effort remained unique. The drop observed in April, when the production reached 10'000 m3/day, had other reasons: the utility was running out of chemicals, mainly aluminum sulfate, and it was not clear when the supply could be renewed. A few tons could be found at the sugar factory, down the river, until the pipeline could be restored, mainly thanks to the ICRC[4], who committed itself to maintain a minimum water production to the town.

In fact, it's the availability of power that defines the level of the production. Power is produced by the hydropower station located just nearby. Out of 3 turbines only one was operational, with a maximum production close to 6 MWh, with the station requiring between 1.2 to 1.6 MWh to be operational, that means to produce and to pump into the network. Other consumers were in need of electrical power and the increased demand during the night, linked, among other obvious reasons, to security considerations, did not allow maintaining the station in operation.

[4] International Committee of the Red Cross

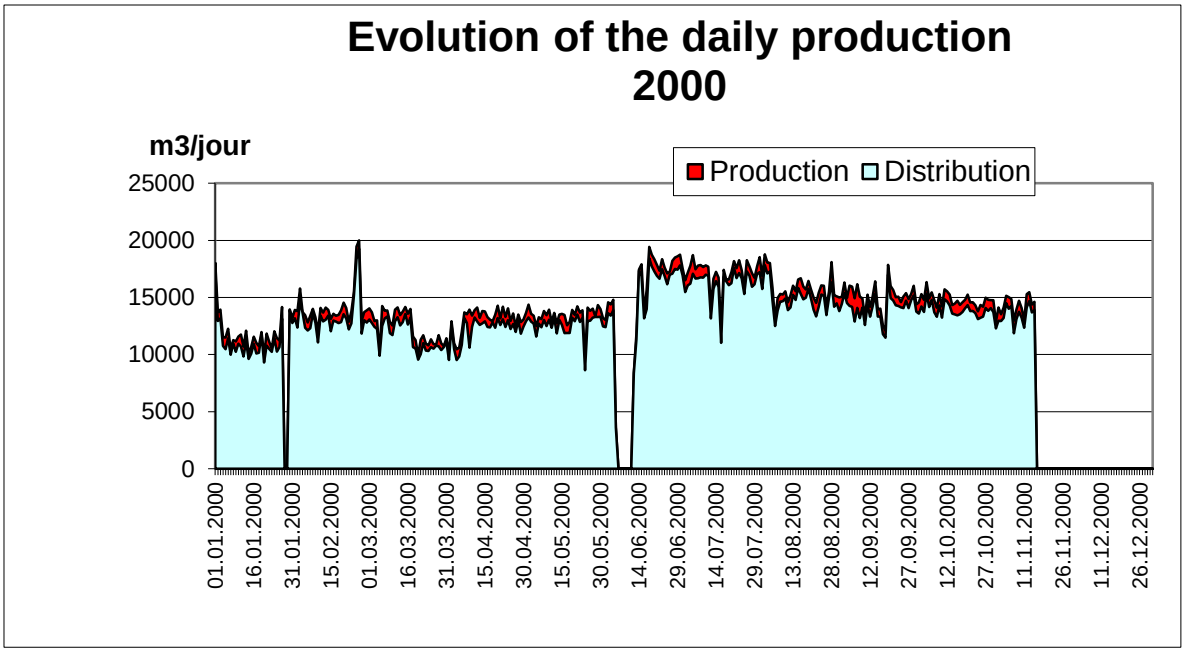


Figure 3 Kisangani WTP : daily production and distribution in 2000 (source REGIDESO)

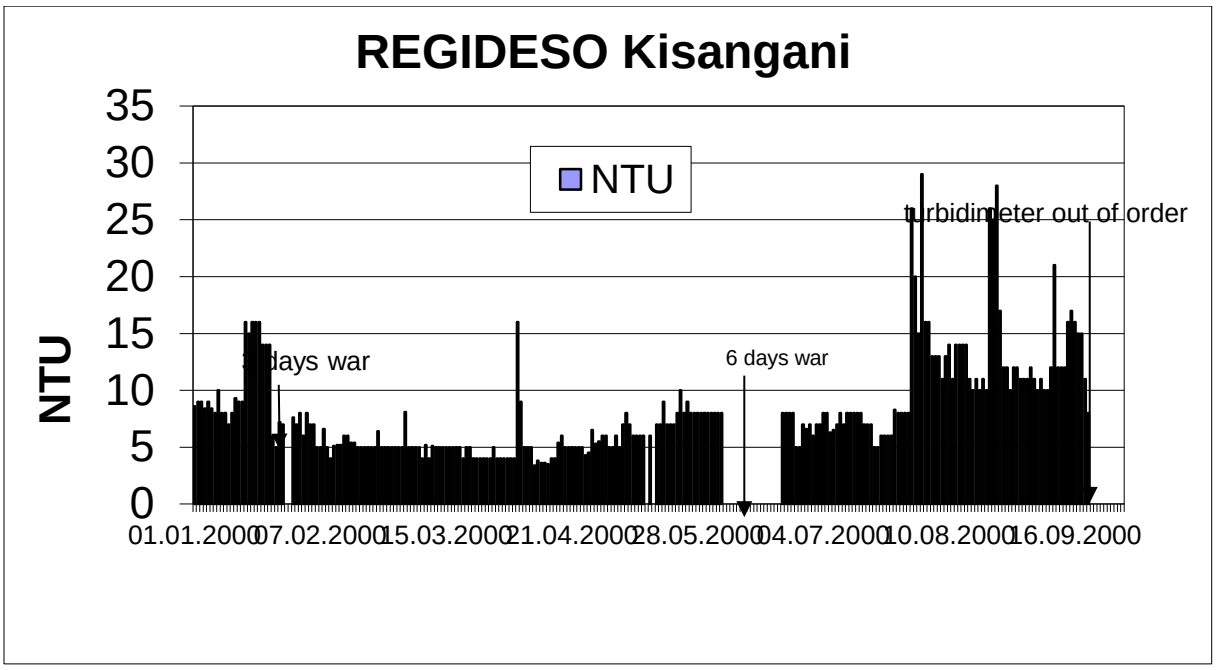


Figure 4 Evolution of the turbidity at the Tshopo WT plant

Beside the problem of the delivery of power, which is the limiting factor here, as nothing can be produced without it, other parameters have to be taken into account, which may also restrict the production. Raw water from the river Tshopo is considered of better quality than that of the Congo. Its turbidity is lower but despite that it has to be treated. The above graph gives the levels of the turbidity of the raw water throughout the whole year, expressed as NTU (Nephelometric Turbidity Units). High levels of turbidity are observed during the rainy season and during episodes of thunder storms. Other parameters to be taken into account are the presence of organic matter, the level of the buffer capacity (alkalinity) and the pH of the water. Other parameters are recorded regularly at the station.

Turbidity is removed to reach the value of 5 NTU with the addition of aluminum sulfate. The water is then filtered on several rapid sand filters and then disinfected with the use of calcium hypo-chlorite and then pumped into the network. The dosage of these chemicals is of paramount importance, particularly

in such situations, where the logistics of their delivery is quite complex and costly. HTH is usually shipped from Kinsasha to Kisangani with barges on the river Zaïre (formerly Congo) and takes at least 3-4 weeks. Due to the disruption of the delivery everything had to be transported by air at a cost close to 2 US $/kg and any save in the daily amounts added to treat the water represented a huge amount of money at the end of the year.

At the same time, a poor removal of the suspended matter decreases the efficiency of the filtration and the operation of back-washing will have to be carried out more frequently. Jar test were carried out daily in order to determine the quantity of chemical to be added to optimize both conditions, a sufficiently low turbidity with the minimum amount of sulfate. Addition of sulfate decreased the pH and lime has to be added to re-establish the value to a level where the formation of the floc was optimal. The relatively complex chemistry involved in such a process is outlined in many text-books[5].

[5] Water treatment in developing countries
Stumm and Morgan, Aquatic chemistry….etc.

Water supply for the town of Goma (DRC)

Introduction

The town of Goma is supplied from lake Kivu. Two pumping stations are operational close to the lake. The water is then chlorinated and distributed through the network.

The pumping station “Turquoise” has been installed after the June 1994 events by the group of French industrial companies Lyonnaise des Eaux, Générale des Eaux (Vivendi), Saur, etc. specially created to address the problem, while the author was involved in the resumption of the production of the station of Gisenyi (Rwanda), crossing the border every day from Goma with a number of former employees of the station.

The other station, named as “lake Kivu” station, was supplying the town through the Mount Goma stations and through the “Tennis” booster. The “Turquoise” station was pumping directly into the network of the low town and supplied also the area of Birere, through the booster station built by the ICRC in 1998 to supply the area located on the eastern side of the airport and reaching the area of Monigi, not supplied previously. All along the pipeline several water kiosks (bornes fontaines) and domestic connections have been connected. The ICRC has also equipped the station with a gen-set to allow for a 24/24 operation. The station is operation almost continuously but may be at standstill when there is no fuel.

Two hotels were under construction and plans have been made to move the “Turquoise “ station close to the lake Kivu one, in order to protect it for any eventual contamination.

The lake Kivu station has a higher capacity and has been equipped with more powerful high lift pumps by THW (Teknische Hilfswerke) and also by OXFAM, who moved some of the pumps which were supplying the refugee camp of Kibumba.

The water lake has a very low turbidity and has only to be chlorinated before distribution. The dosage is high due to the high pH of the water, close to pH 9, and the contact time should be longer due the specific Kab of the acid-base couple HClO/HClO-. The dosing pumps supplied by the ICRC were out of work and beyond any repair. Chlorination was carried out by aspiration directly on the pipeline. Two submersible pumps were out of order and their motors were to be re-winded.

Production/distribution

In the following figure the evolution of the monthly production from 1998 until 2001 is shown. There are no differences between what is pumped from the lake and what is delivered as nothing is added to the water to remove the turbidity, always below 5 NTU, as it is done when the water is pumped from the rivers. The turbidity increases only after any heavy rainfall, when the incoming streams bring suspended solid to the shores of the lake.

Production is halted mainly during power outages of the SNEL (Société Nationale d’Electricité) or during some maintenance works. The amounts pumped have increased regularly since 1998 and have reached the average value of 11’000 m3/day (330’000 m3/month). From the following figure (figure 4) it can be seen that the technical failures have been the main reasons for the low output during 1998 with the outages remaining less important. Not all the stations have been affected in the same way, with the main problems observed at the “Turquoise”.

Consumption of treatment chemicals

The average monthly consumption of HTH (High Title Hypochlorite) during the last three years is shown in the next figure for the 3 different stations. The consumption is directly related to the production, which depends on the reliability of the electricity supply.

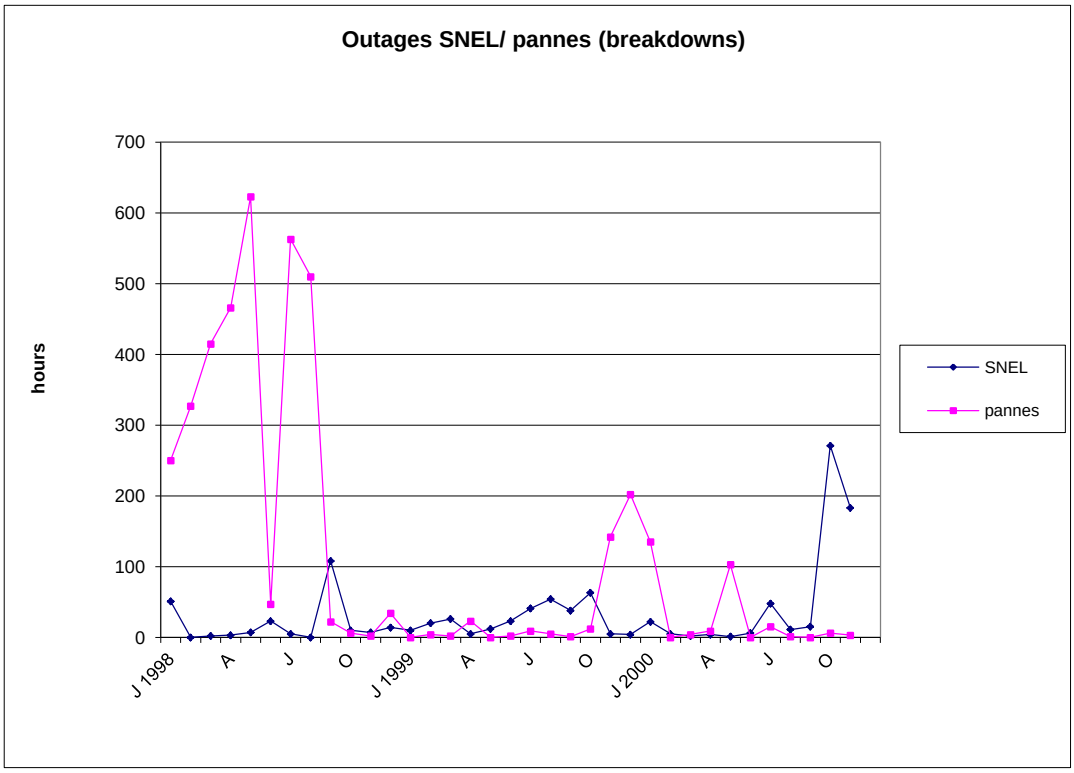


Figure 5 SNEL outages and technical breakdowns at Goma

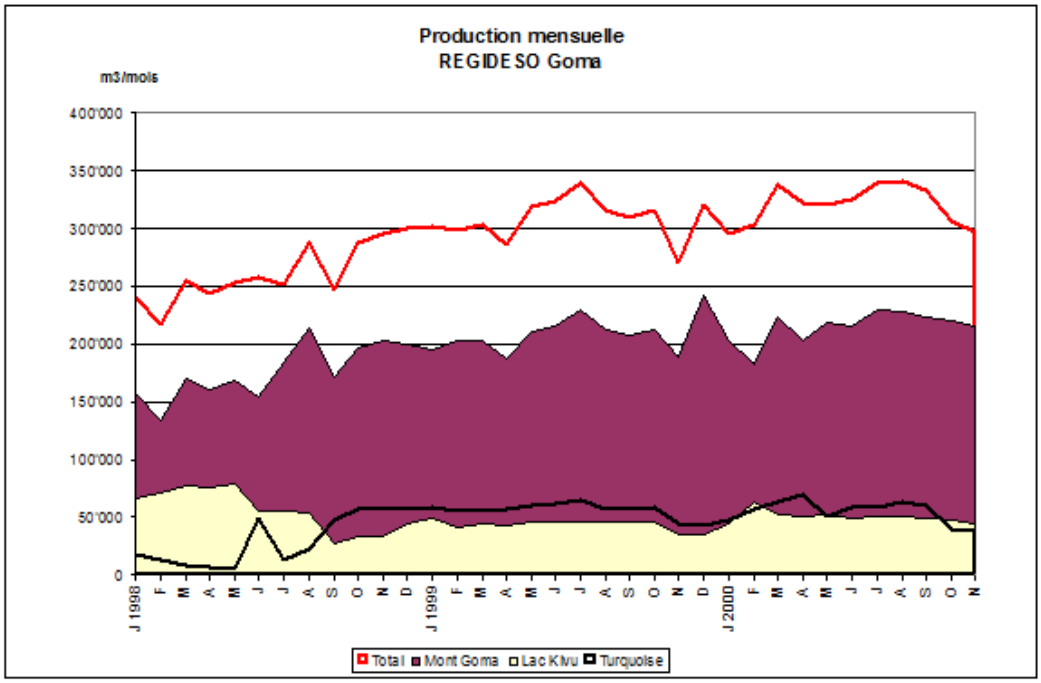
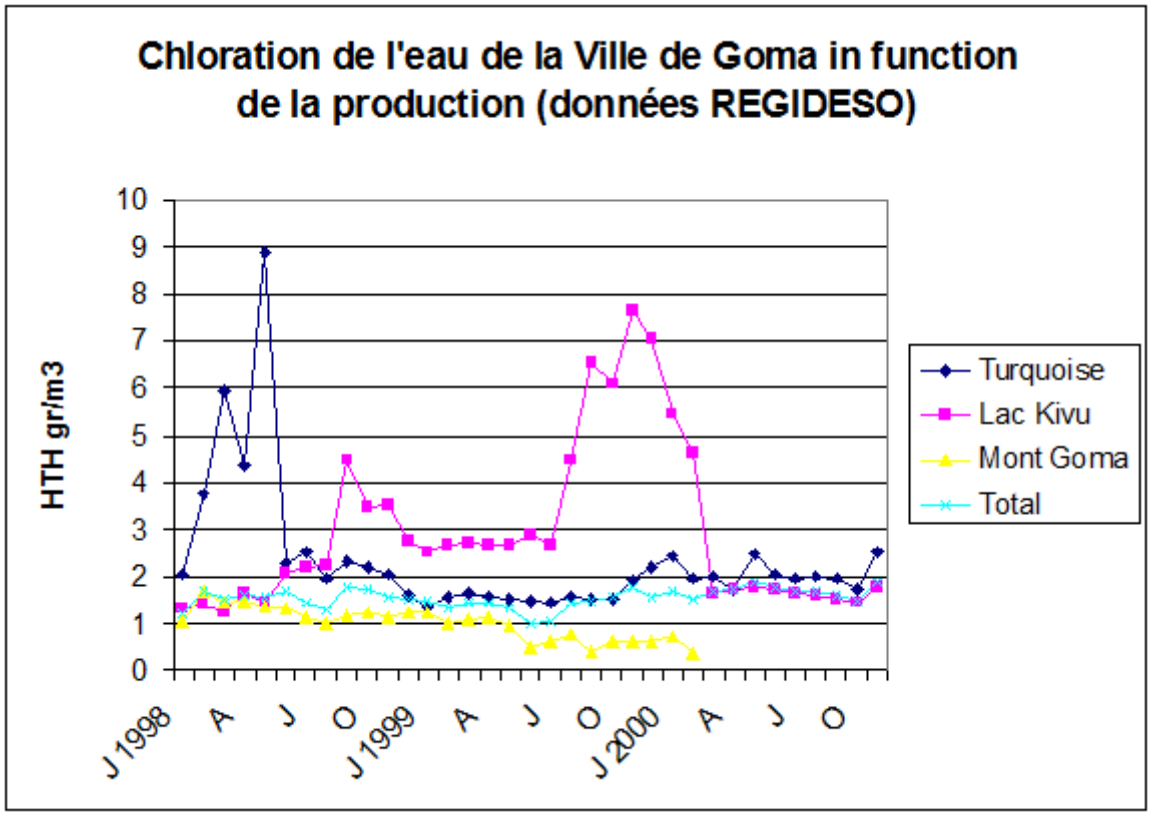


Figure 6 Average monthly production for the Goma pumping stations

Chlorination was carried out at three different points, at the “Turquoise”, at the Lake Kivu station and at the Mount Goma one. Following the above mentioned problems of the dosing pumps, the chlorination point at Mount Goma has been abandoned and chlorine (HTH) has been added only at the lake Kivu station, leaving only two chlorination points. A closer look shows that the dosage of chlorine in mg/m3 is somehow erratic and matches more or less the outages observed above. Mid 1998 things have improved at the “Turquoise” when the new dosing pumps were delivered and the chlorine concentrations have reached values between 2-3 g/m3, but increasing to more than 5 mg/l at the lake



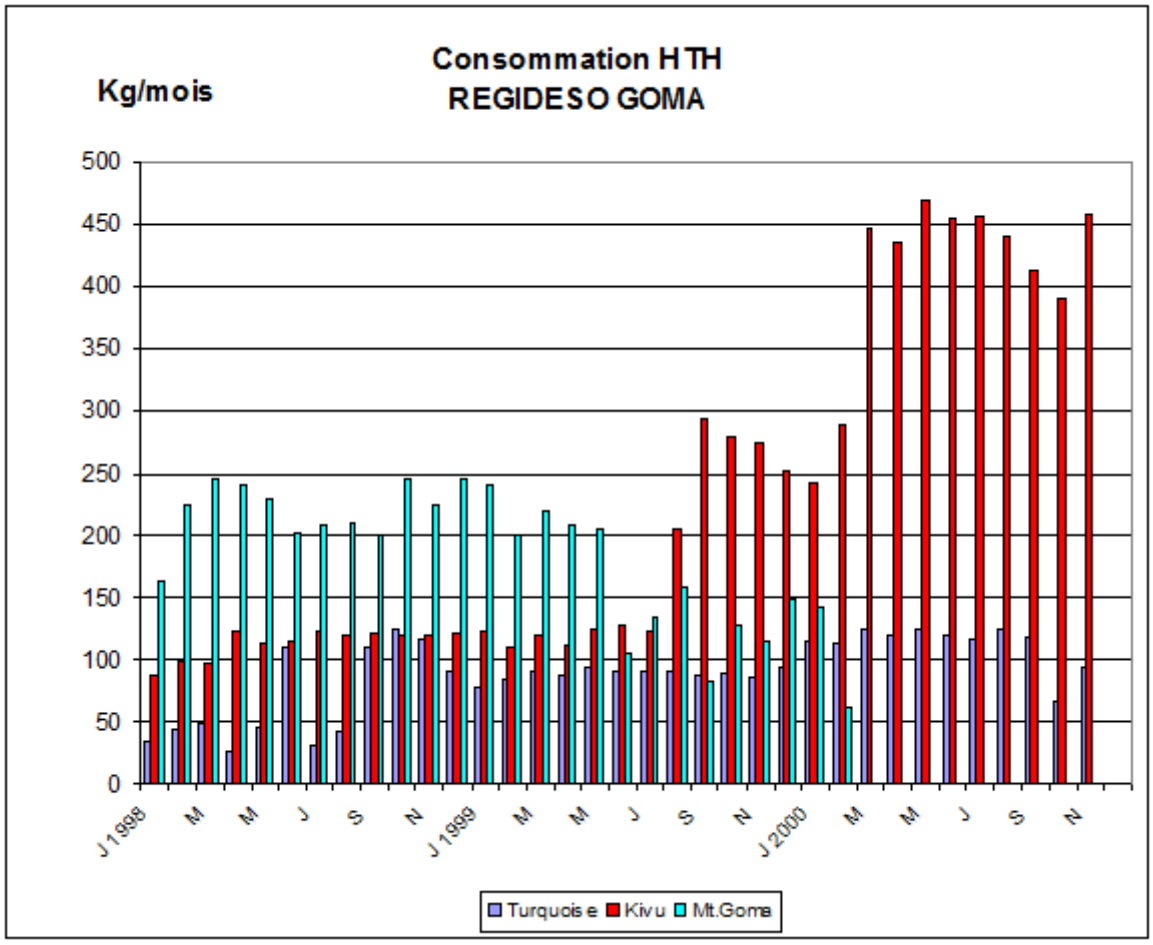


Figure 7 Chlorination of the water: chlorine dosage in g/m3 and use of HTH at the different stations.

Kivu station, beginning of 2000. Finally, levels decreased to normal ones mid- April, close to 2 g HTH/m3.

However the dosing pumps need a constant attention and the utility (Regideso) was looking for cheaper and reliable solutions. Water was due to be pumped to the Mount Goma Storage tank (350 m3) where the chlorine would be added using rota-meters, easier to adjust than the current dosage by aspiration. The contact time with the water would also be longer, the chlorine acting between the Mount Goma storage and the arrival of the storage tank of the booster pump of the “Tennis” station, from where the water will then be pumped into the network. However the Mount Goma storage reservoir was in need of some rehabilitation. More specifically, a new pipeline had to be built and the tightness of the roof had to be improved as well as the painting.

The residual chlorine concentration measured at different ends of the network was always above 0.2 mg/l, even higher, up to 0.5 mg/l, with some values reaching 1.5 mg/l. The last values were probably related to the overdosing problems mentioned above, but the chlorination was working.

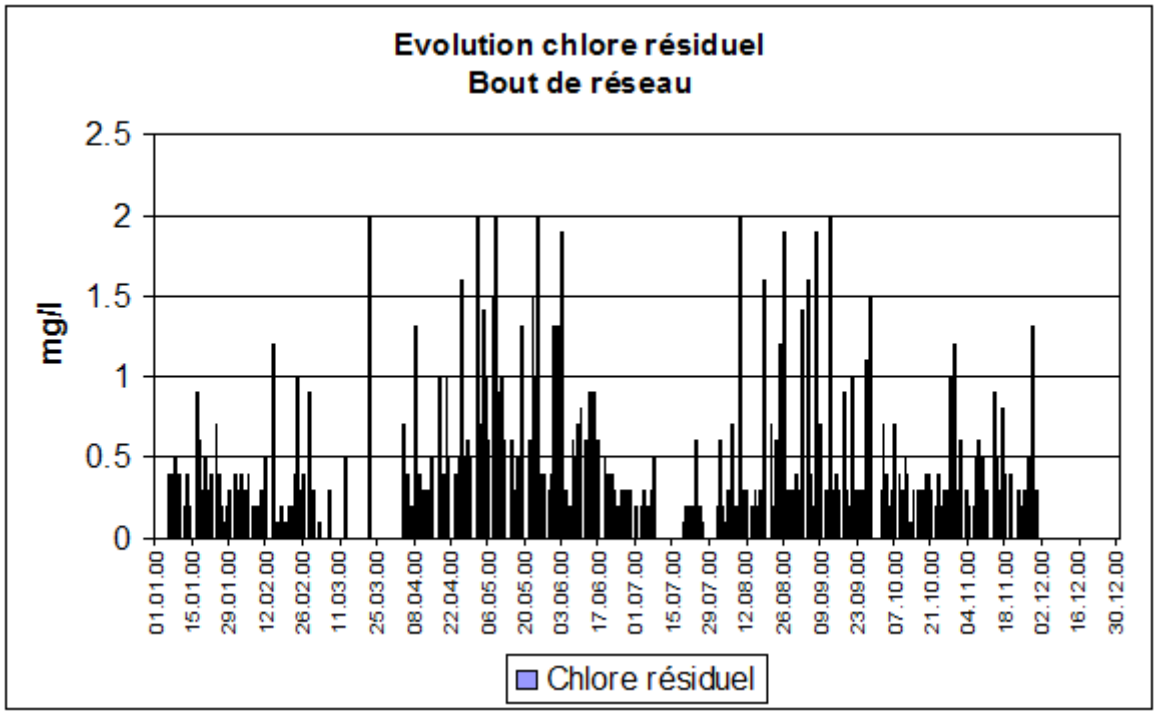


Figure 8 Evolution of the residual chlorine at the end of the network

Filtering media

The ICRC was involved in the financing of the transport of the filtering media for the rapid pressure filters of the station. However the quantity of the sand and to be more precise the effective size (ES) and the degree of uniformity (UD) of the sand grains prepared in Uvira were not as required and some sand was lost, leading to the bypass of the pressure filters. It is unfortunate, as by heavy rains the turbidity of the water at the intake was quite high, and some suspended matter could have been removed if the filters would have been used.

Figure 8 Pressure filters at the Mount Goma station

To improve the filtering effect better sieves had to be supplied to the teams in Uvira in order to allow them to prepare the 20 MT necessary, thus maintaining an activity which would benefit not only Goma, but also the other stations of the south Kivu, like Bukavu, Uvira, Kalémie, Walikale, etc.and those of Beni, Butembu, North to Goma.

Network

The network was one of the problems for the REGIDESO of Goma. The output of the pumps was much too important for the dimensions of the network, particularly for the diameter of the main pipelines.
The pumping capacity has improved considerably when the different INGO (International Non-Governmental Organization) brought in new pumps, which was per se a good approach. However, the next step, the increase of the dimensions of the primary and of the secondary network, was not done. As a result, the head losses and the power consumption were important and water did not reach the remote areas of the town. The low laying areas of the town were fairly well supplied by the “Turquoise station”, which also supplied the Birere booster station, from where the area of Monigi and the different distribution points along the airport road were reached. On the contrary the areas located on the West of the town, on both sides of the road to Sake, were less well supplied. The following figure shows the areas supplied at that time by the network as well the approximate boundaries of the different agencies. As an example, the boundaries of the Katindo agency have been set to match the limits of the water distribution, even if, in principle, this agency is extending much more to the West. In 1996, a German consulting company designed a plan to improve the network and the German Development Bank (K.F.W) was due to finance it. But the war has put everything to a standstill. Some efforts have been done by the ICRC to resume the contacts between the authorities, the REGIDESO and the bank, but with no concrete results.

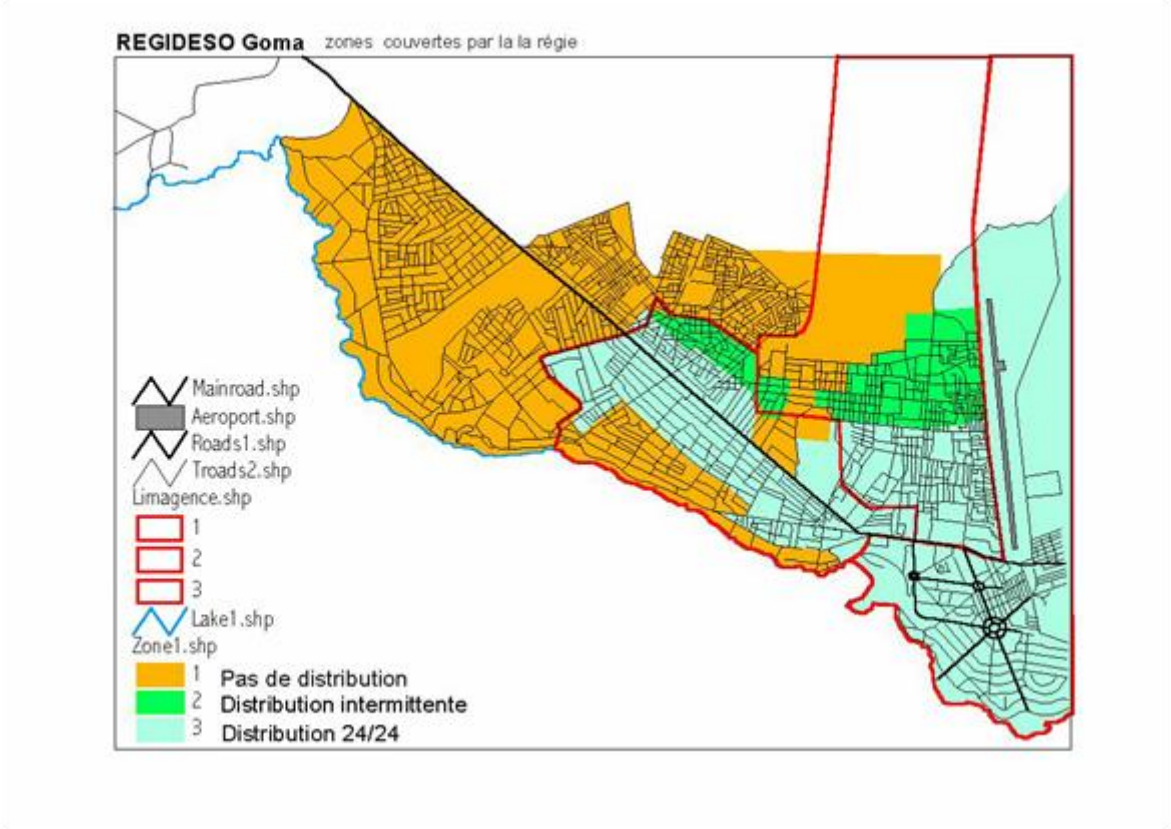


Figure 9 Area supplied and areas without water (a detailed map is shown below).

Pipes were available in Bukavu, but if the transport to Goma (400 kg/6 m pipe) could eventually be organized, the main problem remained the digging of the trenches, which is extremely costly and difficult due to the nature of the ground.

As it can be seen from the above figure, large parts of the town remained to be covered, particularly the area along the lake, on the western side of Mount Goma, where the town was due to grow. Other areas too were poorly supplied, like the suburb of Majengo, located West of the airport. Some hopes

for a better supply were put in the Monigi-Don Bosco project, not yet started, which would connect the pipeline supplying Monigi to the network, West of the airport.

People living outside the blue/green limits in the above figure had to collect water at the water kiosks (bornes-fontaines) at a price of 0.23 USD/m3 or for 5 F.C. for a 20 l jerry-can, or get it from the lake. Most of the residences along the lake were also pumping water from the lake, some with their own chlorination system. Other institutions, like the UPLG (Université de la Province des Grands Lacs) were also getting their water from the lake with their own independent system.

State of the network and interventions

Data for the town were scanty. However, the number of interventions on the primary, secondary and tertiary network for October and November 2000, reported on the table below, would allow thinking that the network was in a fairly good condition. But in this kind of ground, leaks are not apparent and the losses were probably underestimated, with UFW as high as 40% (Unaccounted for water). A leaks search program was due to start but the tools put at the disposal to the REGIDESO never worked.

Month	Leaks	Primary network	Secondary network	Tertiary network	Connections	Total
October	reported	-	2	16	27	45
	repaired	-	2	16	27	45
November	reported	2	5	18	65	90
	repaired	2	2	7	40	51

Table I Interventions on the network

In 1997 a study to reinforce and extend the supply system of the town was commissioned by the REGIDESO to a consulting firm (IGIP) who prepared the technical documents[6] for a population growth of 4.5% between 1994 and 2000 and of 3.4% between 2000 and 2008, leading to an estimated population of 346’203 for 2008 and a water demand of 25’250 m3/day, with UFL estimated at 15% of the total water produced. Several steps were proposed to boost the volume of treated water distributed daily through the network from the 10’000 m3/day to the foreseen 25’250 mentioned above, at the 2008 horizon. The total length of the new pipes of a diameter between 100 to 400 mm was estimated to be close to 27 km for a total length of the network of about 125 km. Only a few of these large diameter pipes were in fact laid, during the presence of the GTZ. The events delayed everything.

On top of that the condition of the meters was poor. Over a total of 3844 meters, 2104 were in a poor condition. **I**nstalling a tested meter and measuring the average monthly consumption was one of the solutions used, but users were restricting their consumption during the tests and then selling the water in order to gain some benefit, with of course a clear loss for the utility.

[6] Republique du Zaire, REGIDESO, Renforcement et extension du système d’alimentation en eau potable de la ville de Goma, dossier d’appel d’offre, IGIP, Ingénieurs conséils, Darmstadt, Février 1997.

Goma		Remarques	Billing		01.10.2000
Nominal capacity	630'000 m3/month		Domestic	51,20%	
Functional capacity	280'800 m3/month		Industrial	0.4%	
No. of customers	4 932	Abonnés	Intermediate	2.7%	
No. of active customers	3 905		Water kiosks (BF)	4.9%	
Length of the network	101 km		Businesses	7.4%	
Year of layout	1950-54		Agents REGIDESO	2.8%	
Agencies	3		Total billing	1'935'077 F.C.	1 US $= 45 F.C.
No. of meters	3 844	2104 in poor condit.	I.O. (Official Institutions)	592'943 F.C.	
Network efficiency	60%		Recovery rate	28%	01.11.2000
Hours of operation	24/24 h		**Employees**		
Energy kWH/month			Total	69	
Instances officielles	30%		Production	29	15 for the stations
			Maintenance teams	5	1 HQ, 3 for the agencies
					and 1 for the equipement

Table II Goma : data for the utility

Water kiosks (bornes fontaines)

There were 102 water kiosks within the town. Not all were supplied on a 24/24 basis. A large part of them was getting water only during the night. The water is stored in the tanks and the people can draw it during the day at a cost of 0.2 FC./ 20 l jerry-can (about 20 cts. of USD/m3). The total volume sold at the water kiosks was about 8470 m3/month in November 2000. According to the REGIDESO this represented about 5% of the billed quantities, with the amounts billed to the domestic customers being of about 51 % and the remaining 31% billed to the I.O. (Institutions Officielles) and other categories, at it is shown in the next figure.

8470 m3/month were corresponding to about 1950 USD, assuming a billed rate of 0.23 USD/m3 (about 0.005 USD) for a total of about 1950 USD. The recovery rate at the water kiosks can be considered high, probably higher than 90 %, as the people have to pay during the collection. It was and still is a reliable source of income for the utility. On the contrary the I.O. (hospitals, administrative buildings, etc,) did not pay their bills. With a recovery rate of 28 % of the total amount billed of 1'342'000 F.C. (excluding the I.O.) the monthly income for the utility was close to 375'000 F.C. Which represented about 8350 USD at the official conversion rate used, fixed at 1 USD = 45 F.C. It was not clear if this recovery rate was including the amounts billed to the water kiosks, but more or less, one could estimate the monthly revenue of the REGIDESO was close to 10'000 USD.

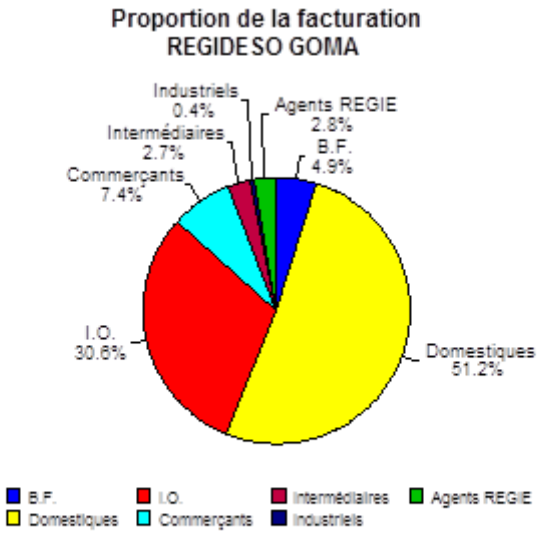


Figure 10 Billing for the different categories of customers

Conflicts evolution of between residents and displaced people, within Goma and in the outskirts of the town and consequences on the water supply.

The inhabitants of the town of Goma (RDC) have experienced quite number of water supply cuts since the events of 1994 and 1997, mainly related to the lack of power, supplied from the Ruzizi power station, located near Bukavu.

Many emergency interventions have contributed to solve some of these problems, and if the network distribution within the town has generally resumed to “normal”, some areas have remained without water, due to huge pressure losses within the undersized pipelines and losses due to leaks within the network.

The area located East and North of the airport were among the area which remained poorly supplied.

The Birere pumping station has been built by GTZ (German Technische Zusammenarbeit) and was meant to boost water to the airport and to Munigi, where about 5000 people were in dire need of water. The pumps were installed directly on the network line but never worked satisfactorily and the REGIDESO decided to disconnect them (see figure 11).

The problem of the supply to the 19’000 inhabitants living in the area of the airport and in Munigi had to be addressed. Moreover, end of 1997, the water situation in Munigi was aggravated by the arrival of about 5000 displaced people, leaving the villages north of Goma, affected by violent conflict. Water was available downtown, at about 7 km from Monigi, but queues were long at the water kiosks, already under pressure, and tensions between the different users quite frequent and on the increase. End of 1998 the ICRC decided to rehabilitate the distribution system to the area and extend the network to Munigi, in order to improve the supply of its inhabitants and of the displaced and, at the same time that of the people living along the airport road.

The construction of a new storage reservoir of 90 m3 at the Birere pumping house, the rehabilitation of the pumping station of Birere, the replacement of the existing supply main over 3.6 km and the its 1.5 km extension to Monigi, where a storage reservoir of 100 m3 and several water kiosks were built, were completed by July 1999. Between Birere and the airport, 8 water kiosks were also built to supply the inhabitants of the suburb of Kahembe. The supply of the 100 m3 reservoir of the airport was also improved.

The inhabitants of Monigi were organised in a users’s committee and water was paid regularly to the REGIDESO according to the metered quantities.

Recent evolution of the situation and consequences

With the arrival of the MONUC (Mission d’observation des Nations Unies au Congo), early 2002, the situation of the access to water for the inhabitants of Monigi has changed drastically. The MONUC headquarters have been set up East of the airport, along the road to Rutshuru, and a military camp within the airport itself, for a total number of about 1500 soldiers. Several reservoirs have been installed within these premises, supplied by the same line from the Birere pumping station. Other important consumers, like the Supermatch factory and many other users were connected to this line.

As nothing has been changed at the station, designed for the a/m project but without little possibilities for any further improvement, water stopped to reach the Monigi reservoir, being almost exclusively used be these important consumers, located between the airport and the pumping station.

Despite many requests to the REGIDESO addressed by the inhabitants the situation did not change. Beginning of 2006, the situation was even made worse by the frequent power cuts and due to mechanical failure of one of the two pumps. The generator set, installed to cope with the power cuts was rarely used due to lack of fuel.

The inhabitants of Monigi have to rely on distribution by private tankers or have to reach the area of the water kiosks still operational, if they want to access a minimum of water. Water can reach 400-500 FC per/ 25 l jerry-can (about 1 US $), compared to about 1 US $ / m3 when it is sold at the water kiosks, about 40 times more. Once a while, when there is regular supply of power and when the two

pumps were working, water would reach some of the water kiosks located between the airport and Monigi.

Consequences on the access to water due to the expansion of the town during the war and after the volcano eruption of 17 January 2002.

The population of the town has increased dramatically between 1994 and 2004. Several factors have contributed to this:

- *the arrival of internally displaced people within the outskirts of the town, leaving the violent confrontations occurring within the rural areas close to the town, where the security is considered less well addressed by the ruling authorities*

- *by people economically motivated migrating to town looking for better opportunities, linked to the presence of international organisation (UN, NGO, INGO, etc) and the "booming" economy*

Population figures for the town have been obtained from the Mayor's office and are reported in the next table, per suburbs. After the eruption of the volcano, dramatic shifts of the population patterns have been observed, requiring the redefinition of the boundaries of the municipalities ("communes") and the creation of new ones.

Table III Evolution of the population of the town of Goma since 1994

Commune	Pop 1994	Pop 2000	Pop 2002	Pop 2004
Himbi[1]	n.ex.		20'927	28'412
Kahembe	13'270		23'278	26'555
Katindo	23'931		24'625	28'230
Katoyi	15'915		34'531	42'818
Keshero[3]	--		14''089	29'324
Kasika[2]				
Mabanga North[6]	22'212		39'955	45'656
Mabanga south	--		88'539	77'317
Majengo	10'009		11'690	19'088
Mikeno	47'819		36'995	38'575
Murara	14'478		13'761	30'036
Ndosho	3'406		12'068	25'743
Virunga	15'010		2'651	8'782
Volcans	17'562		10'466	11'575
Mugunga[4]	n.ex.		n.ex	6'233
Bujovu[5]				11'899
Total	183'612 [7]	353'181	414'536	504'056

1 was part of Katindo

2 created after the eruption

3 was merged with Ndosho up to 2003

4 was created after the eruption

5 was created after the eruption and includes Monigi, with a population estimated at 5000 inhabitants plus about 5000 displaced people

6 was split into North and South

7 the figure is slighlty lower than what is reported in the reference quoted (187'000).

In these figures the dramatic arrival of the Rwandan refugees escaping the aftermath of the genocide in 1994 are not included (estimated to 1'000'000), as they were mainly confined to camps. The impact of the cholera epidemics and its 30'000 deaths on the population of the town is not quantified too, as

the majority of the deaths have been refugees. The figures are subject to caveats, but the increase between 1994 and 2002 is striking, as well as the data for 2004. The figures are supported by the tremendous increase of the urbanised areas in the Eastern part of the town, where the number of houses was scanty until 2002.[7] Over a sample of 2052 houses, about 40 % have changed their address after the eruption, looking for a safer area.

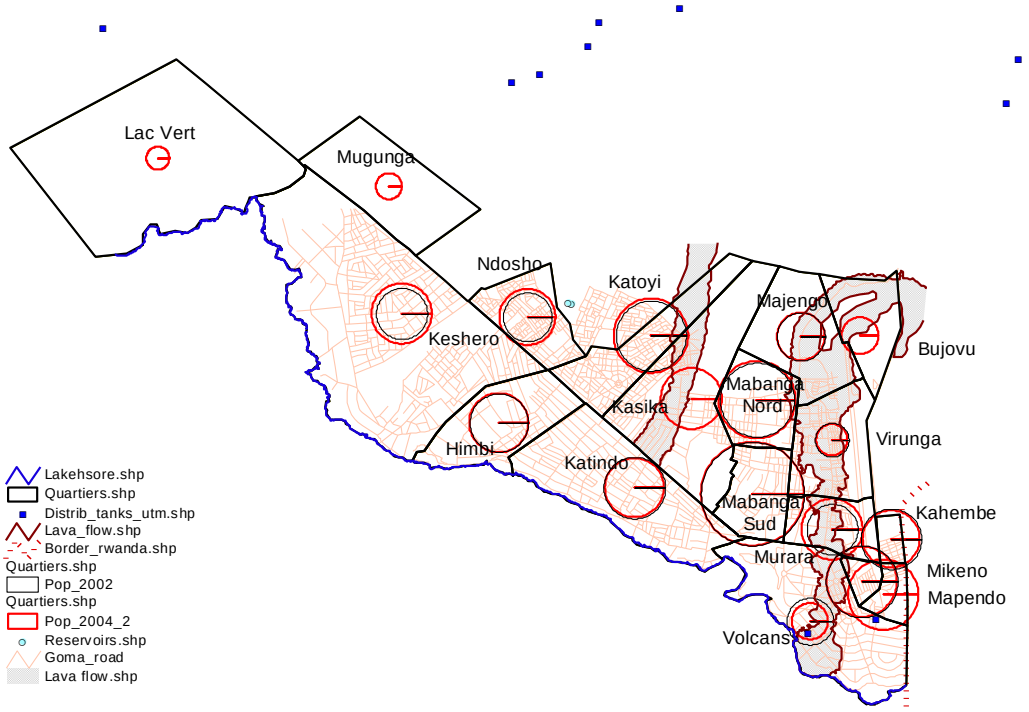


Figure 11 Changes in the occupation of land for Goma

Impact on the water distribution

The two major events which did affect the town of Goma had different impacts on its water supply system.

As outlined above, the massive and sudden arrival of the refugees and the consequent creation of the refugee camps outside the town of Goma did not affect dramatically the network distribution. Most of the water used in the camps at the beginning of the emergency response set up by the different INGO present (SCF, MSFBelgium, etc.) and by the army, was pumped directly from the lake into water tankers, sometimes of doubtful conditions, chlorinated and trucked to the temporary camps, until more permanent solutions could be found. A major change for the network distribution was the installation, mid 1994, of the new pumping station, named “Turquoise”, close to the Grande Barrière. This station was able to pump roughly 70 m3/h (50’000 m3/month) into the network supplying the lower part of the town, up to the Birere booster station, contributing up to 15 % of the total production pumped into the network.

The cholera epidemic did not affect the town population, at least not via the water pumped through the

[7] RDC, Etude globale sur la situation des ménages dans la ville de Goma après l’éruption du volcan Nyiragongo le 17 janvier 2002. Rapport d’analyse, Institut supérieur d’informatique et de gestion, Goma, juillet 2003.

network. The epidemic of cholera was affecting mainly the refugees living in the makeshift camps, leading to the extremely high number of deaths, estimated to be of about 30'000. Town inhabitants not connected to the network and refugees still living in the outskirts of the town, mainly on its western bounds, were also affected and may have contributed to the spread of the epidemic. Refugees were collecting water at the shores of the lake, obviously contaminating it, during the early days of their arrival. The pumps installed by OXFAM to supply the camp of Kibumba (population in 1998 estimated to 20'000) with chlorinated water were lately removed and installed in 1998-2000 at the lake Kivu station, to strengthens its pumping capacity.

Figure 12 Chlorination of the jerry-cans and people fetching water at lake Kivu

The town began to expand, as new opportunities were growing, enhanced by the arrival of many INGOs (International non-governmental organisations) but the network remained more or less the same.
People living in the "quartiers" of Ndodho, Keshero and Katindo, not supplied by the network, began to collect water regularly at the lake. Chlorination points were established by the ICRC via a local NGO, AMIKIVU, along the shore, where access to public was possible, in order to minimize any possible outbreak of cholera. As the town grew the number of people collecting in this way was constantly increasing as no other access was possible. Possible solutions to extend the network to cover this part of the town were limited by its hydraulic capacity, designed according to a master plan prepared in 1984 with the support of the EC, to supply a population of about 200'000 inhabitants.

Beginning of 2001, the possible relocation of the Turquoise station was also taken into consideration, as many new constructions were under way in the area, and fears were growing that contaminated water would be pumped into the network.

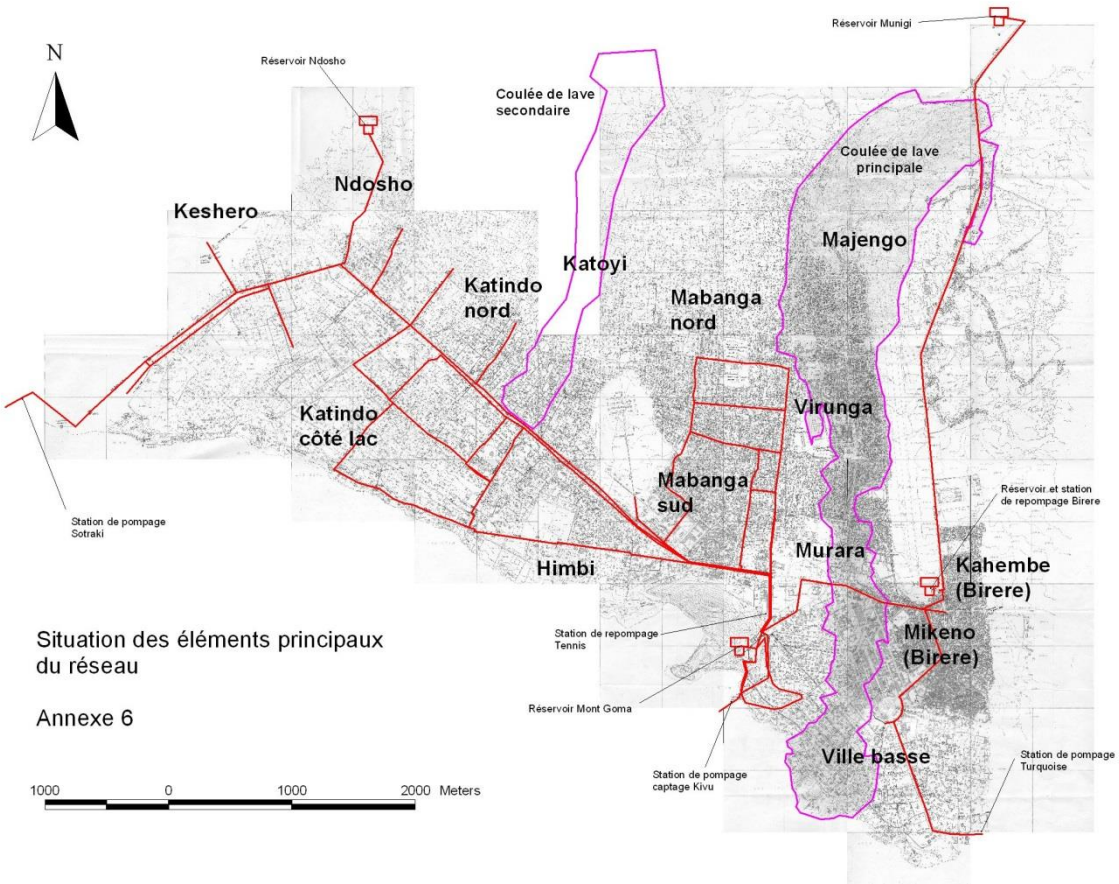
The eruption of the Niyragongo (17 January 2002)

The consequences of the eruption on the water distribution have been dramatic.

- 8,6 km ^{2} of the total surface of the town were covered and destroyed (13 % of the official surface of the town (33.079 km^2 Goma and 33.373 km^2 for Karisimbi)
- 5000 houses have been destroyed
- 17'481 households have been affected
- the urban commercial centre has been destroyed to up to 80 %
- 45 schools have been destroyed
- 27 health structures have been destroyed (among them 3 hospitals)
- 1/3 of the airport runway has been covered by the lava (1 km)
- 32 km of tarmac roads have been covered
- 21.9 km of water pipes and 20 manholes have been covered by the lava

Consequences on the water distribution system

The lines supplying the Eastern part of the town were damaged. Only one distribution line was re-established. The problem of the massive relocation of the population toward the Western bounds of the town had to be addressed. The chlorination of the water collected directly at the lake was resumed and increased. The Keshero (Sotraki) pumping station was made operational and the line distributing water to Himbi, Keshero, Ndosho was re-enforced with a galvanised iron pipeline of 200, respectively 150 mm of diameter. The proposals of the IGIP study were reconsidered and a new study to modelise the network was undertaken.



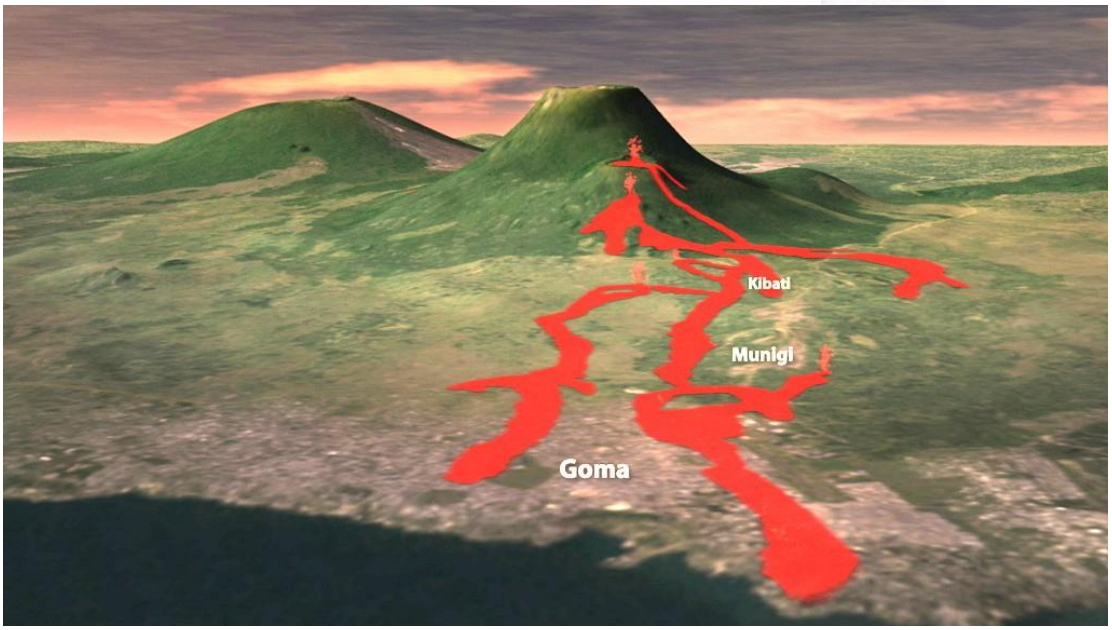


Figure 13 Network and area affected by the lava

A joint project with the REGIDESO was implemented to allow supplying the new urbanised areas from the Keshero pumping station. Two storage reservoirs of 200 m3 each were built in the highest area of Ndosho and plans were drawn to re-build the pumping station and to replace the already re-enforced pipeline, on which many new connections were made. Its diameter was already too small to supply the reservoirs and a new line had to be installed. Early 2005 the reservoirs were completed but the final design of the pumping station was not yet approved by the technical department of the REGIDESO headquarters, with the consequent delay of the implementation by the ICRC. The new pipes of 300 mm of diameter, to be transported from Bukavu and from Uvira under the responsibility of the utility, were not yet available and were anyway not sufficient to cover the whole distance. The remaining length, of about 3 km, would have to be purchased under the PUSPRESS programme of the World Bank. After an initial study carried out by a consulting firm, a consortium of other consultants named MODRU was charged to hire a consultant to carry out the final tender document for the rehabilitation of the network and of the pumping stations, almost two years after the initial commitment of the funds.

Little initial interest was shown by the different consultants to integrate in their approach the changes in the spatial urbanisation of the town, their intervention being focused to replace what was damaged by the eruption, due to internal administrative constraints. Only at a later stage, a more reasonable approach was found, but precious time and funds were lost.

Main local interventions

The ICRC has done an initial support of the utility with salary incentives to maintain a minimum operational capacity of its personnel and has gradually decreased its support with time, when the situation has become slightly better.

Training courses have been organised to maintain and improve the knowledge of the different operators who remained within the utility.

Chemicals to treat the water were purchased and put at the disposal of the utility, until its financial situation was allowing the REGIDESO of Goma to take over this essential step of the water distribution. A local NGO (AmiKivu) was supported with chemicals and incentives to set up and operate chlorination points along the shores of the lake, where people not supplied by the network were collecting water.

The REGIDESO has also been assisted during the emergency period following the volcano eruption, to re-establish a minimum supply to the eastern part of the town. A study was carried out to modelise the network with the aim to define where and how the network would have to be improved, using elements from previous data. 3 new high lift pumps were installed at the main lake Kivu pumping station. A new pumping station was made operational at the western bounds of the town to supply the new urbanised areas. After the volcano eruption, the diameter of the pipeline was increased and a preferential line to power the pumps was built, in partnership with the SNEL. A support was given to build the new pipeline supplying the Mount Goma storage reservoir in order to improve the load at the Tennis booster station.

Figure 14 New reservoirs built East of Mt. Goma

Two new reservoirs of 200 m3 capacity have been built by the ICRC in Ndosho and an agreement was signed with the utility to supply them

from the Keshero (Sotraki) pumping station, to be rebuilt completely by the ICRC in 2006. The new pipeline with a higher diameter would then be built by the REGIDESO, with a support from the World Bank, in the framework of the PUSPRESS agreement.

Several gravity systems were built in the rural area, in partnership with the SNHR (Service National d'hydraulique rurale) to supply medium size localities, like Burengu, Masisi town, etc.

Discussion

The town of Goma, like many other towns in a similar situation, has more than doubled its population during the last 10 years. It seems that new opportunities and poor security within the hinterland have enhanced the process, despite the onset of two major events affecting the already precarious state of the municipal services, the arrival of the refugees in 1994 and the eruption of the volcano Niyragongo in 2002. Interventions must integrate such facts.
Normal development programmes have stopped already in the late '90, when all the funding bodies left, like the EU, KfW, Bad, WB, GTZ, etc.

In war or post war situation a particular effort should be given to support and strengthen the utility to maintain and improve its operational capacities, in order to reach pre-war level at least, despite the drastic evolution of the situation. Basic treatment chemicals, equipment and spare parts should be part of the initial support package and the length of this support may often exceed a period of one year and is more likely to last for 3-5 years.

Local staff should not be enrolled by incoming INGO's, or other international actors. On the contrary, efforts should be directed to improve the already fragile capacities of the water utilities and maintain its personnel within the utility. Capacity building interventions should be initiated and incentives supplied.

International NGO had to implement emergency interventions as well as development-like ones, to cope with the events and with the population increase. The horizon was difficult to evaluate as the dynamic of the population evolution were not known, but were definitely **shorter** than the normal ones used in the sector.

The central structure of the REGIDESO remained alive at the country level, delaying any decision at the local level for projects aimed to respond to the dramatic evolution of the situation, leading to a "non-development" of the already poor infrastructure supplying the population. At the same time the normal support to the utilities, like training, design of schemes, etc. has disappeared, with a consequent loss of competences and motivation.

The quality and the magnitude of the maintenance have dropped significantly and were restricted to reactive interventions, when a problem occurred.

The conflict situation has led to hyperinflation, with constant depreciation of the local currency toward the hard ones, enhancing the problem of external purchase of current treatment chemicals and spare parts. The INGO and the huge influx of hard currencies may have played an important role.
The financial recovery was and still is slow, as utilities may have to use their income to support other efforts.

Emergency programmes implemented by donors used to work in normal situations are prone to fail, due to inadequate implementation procedures and little flexibility. Despite the importance of the funds, their impact to respond to the new needs is poor. When the initial study was completed the situation has already evolved and the proposed response was obsolete.

Emergency programmes aimed to cope with the lack of development projects, implemented in partnership with local actors have to be carefully analysed. The commitment of the local partner and its capacity to fulfil his part of the agreement were often overrated, leading to important delays. The magnitude of these projects was limited and their integration and hand-over to incoming major donors was not adequate.