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(Research Article)

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Quality and security of drinking water supply in the south of the Democratic Republic of Congo

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Abstract

The objective of the present study was to evaluate the quality of the different sources of drinking water supply, the impacts of poor management of conveyance systems on the quality of drinking water and its possible consequences on human health. and describe the potential for contamination or deterioration of water in the system. 4881 households were visited and responded to our questionnaire. From our results, the distribution processes, the poor use of polyvinyl chloride (PVC), or galvanized pipes as well as the management of fountains constitute the major elements which influence the quality of the water consumed by the population of Lubumbashi and thus exposing them to diseases due to microbial and allergic contamination. An approach, not only to raise awareness among the community that this would be necessary, but also, standardized training in the matter must be carried out for the benefit of each user of both the public water distribution network and boreholes as well as the fountains.

Keywords: Drinking water; Supply; Quality; Safesty

1 Introduction

The availability of clean drinking water is a universal human right. Water quality differs between communities. When the quality is good, community members are the first beneficiaries, but they are also the first to suffer the consequences of deteriorating water quality. In most communities, residents can determine whether their drinking water is safe and of good quality based on its organoleptic properties. Poor quality of drinking water is due to poor waste disposal, poor treatment, poor maintenance of systems, flooding, political interference, lack of urban planning, increased population growth and water hyacinth. Community awareness, community participation[1].

The development of society and industry around the world is closely linked to the availability of water[2]. The southern region of the Democratic Republic of Congo has unique characteristics that have always made providing water to local communities and industries a challenge. First of all, the region is home to a large expanse of mining, the richest in the world. namely copper. Cobalt, Zinc, iron, Cadmium, gold[3]…The historic shortage of fresh water is currently aggravated by the effects of climate change [4]. Secondly, the region's surface watercourses are not only rare, but also of poor quality, due to their high salinity and high chemical element content [5] in view of the negative impact of the fact that the region is a significant reserve of copper, lithium, molybdenum, and natural nitrates [6]. Today, new housing developments require private water supply either by manual or industrial drilling, the depths of which vary from one region to another and whose supply network uses polyvinyl chloride (PVC) pipes, abandoning such as galvanized pipes. Failing to consume borehole water, the population resorts to water distribution fountains in homes. And these also do not require periodic maintenance. All this, in a context of continued growth in the extraction of minerals and metals, has generated significant economic benefit for the country, but at the same time has increased pressure on water resources.

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The presence of certain contaminants in our water can lead to health problems, including gastrointestinal illnesses, reproductive problems, and neurological disorders. Infants, young children, pregnant women, the elderly, and people with weakened immune systems may be at particular risk of illness.

The above sum of concerns motivated this study; whose objectives are as follows:

Identify the water supply systems in the community, while specifying the characteristics associated with each system in terms of network types,

2 Material and methods

This is a prospective cross-sectional descriptive study, with a systematic documentary research strategy based on a quiz on Google form and direct observation of the facts declared by the participant in this study, whose household agreed to open to us its door and having given its favorable opinion to respond to our quiz was included in this study.

For data extraction, we used a standard data extraction format prepared in Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

The quality of the data was assessed by two analysts who independently assessed the quality of the data included by verifying the completeness of the inclusion criteria. A disagreement between the two analysts was resolved by discussion. Data analysis was carried out using Epi Info 7.2.5 and Excel software.

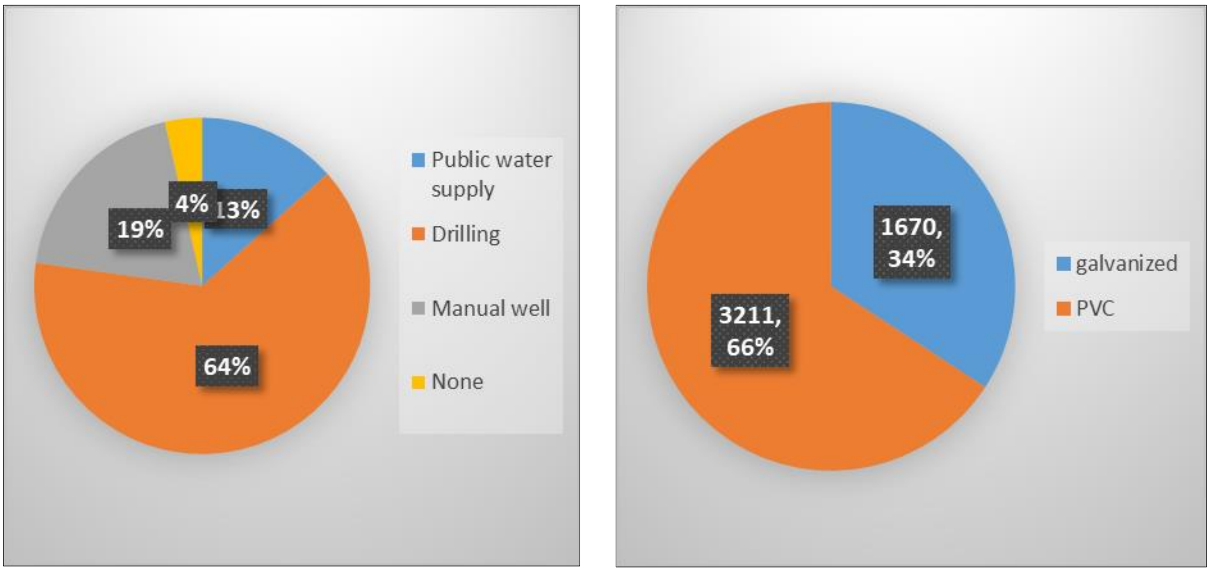

Figure 1 Distribution of data according to types of water supply and types of pipes used

From Figure 1, we observe that most homes, 64%, use borehole water and manual water (19%) and 13% are connected to the public network. Only 4% of the homes visited do not have a water supply. All these homes mainly use Polyvinyl Chloride (PVC) pipes, i.e. 66%. These results depart from the work of Tong et al carried out in Nigeria whose results showed that manual water collection from hand-dug wells predominated in the study area with 86.15%, while 9 .23% and 4.62% used motorized and motorized modes respectively [7]

Inadequacies in water supply have adverse health effects, both directly and indirectly. Insufficient water supply also prevents good sanitation and hygiene. Therefore, improving various aspects of water supply represents important opportunities to improve public health[8] .

Galvanized steel plumbing pipes are steel pipes coated with zinc to prevent rust. Galvanized steel corrodes over time, and it's almost impossible to tell what's happening just by looking at the pipes from the outside. Pipes rust from the inside out, causing poor structural properties leading to leaks and collapses. They will also develop calcium deposits inside the pipe. These pipes can eventually become completely clogged with calcium buildup, leading to low water pressure and rusty water. Galvanized steel pipes have an average lifespan of 40 to 50 years.[9]

Galvanized pipes have been found to accumulate lead that leached into the water from old lead service lines. As galvanized plumbing corrodes (as it inevitably will), it releases accumulated lead into the water.[10,11] This explains why a higher incidence of elevated blood lead levels in children has been reported in homes where pipes had been partially replaced compared to undisturbed lead water pipes, and higher rates of fetal death were observed during periods of partial plumbing. pipe replacements.[12,13]

Also, poly(vinyl chloride) is a common plastic widely used in many industrial applications and plastics are widely used to replace metals, glass, and wood in many modern applications [14]. Plastics have unique performances and superior properties compared to other materials [15]. Plastic properties such as toughness, stiffness, density, color and transparency can be controlled during the manufacturing process. Additionally, plastics can be produced cheaply and last a long time.[16] PVC undergoes gradual degradation in harsh environments, such as under exposure to heat and direct ultraviolet (UV) light for a long time [17]. The degradation of PVC leads to a reduction in its mechanical integrity, a change in color and the formation of microcracks within the surface. Indeed, the photooxidation of PVC causes the crosslinking of polymer chains due to the production of free radical fragments. As a result, hydrogen chloride (dehydrochlorination) and small volatile organic residues are eliminated, accompanied by discoloration of the PVC. Such processes lead to weight loss at various relatively high temperatures[18]. This is exactly what happens when PVC pipes are exposed to the sun in the situation of conveyance networks with surface piping because PVC, which is particularly susceptible to damage caused by UV rays from the sun[19].

However, at high temperatures, heated PVC vapors may contribute to the development of asthma in adults. Epidemiological studies in children show associations between indicators of phthalate exposure in the home and risk of asthma and allergies. The lack of objective information on exposure limits epidemiological data[20].

Table 1 Depth of wells

	mini	Average	STD	Fashion	Median	Max
Manual Well	1	17	3-21	20	23	45
Well drilling	35	61	15-22	60	62	80

The average depth of wells is 17 m for hand dug wells, most of which measure 20 m and 61 m for boreholes and 62 m with most going up to 80 m.

The depth of wells is an important element in assessing water quality, because in many urban and peri-urban areas of developing countries, shallow wells and untreated water from urban rivers are used for domestic purposes, for the supply of drinking water, bathing of the population and irrigation for urban agriculture. Regular assessment and monitoring of water quality is necessary to prevent potential human risks associated with exposure to contaminated water[21].and several studies in DR Congo[pr]or Uganda [22.23]

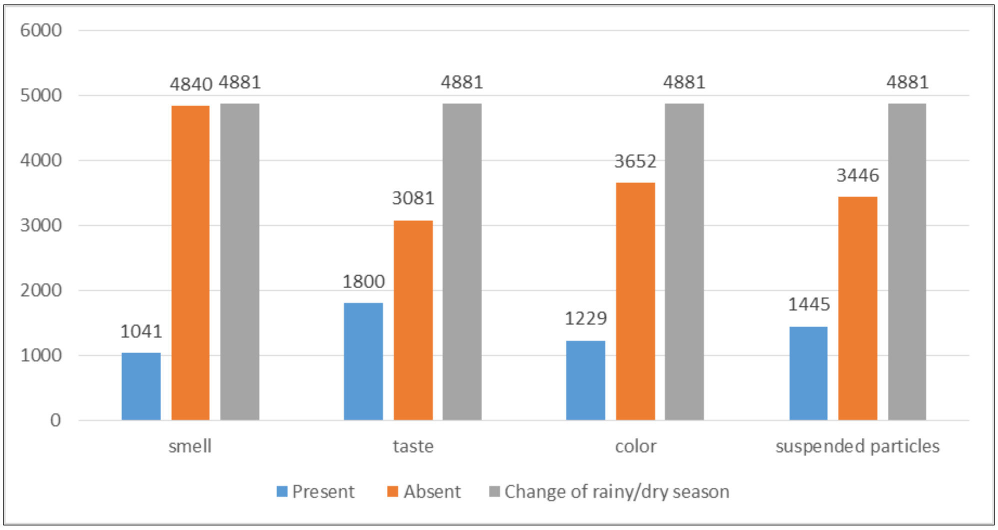

Figure 2 Characteristics of water in normal flow

Regarding the characteristics of water according to consumers, we note that the characteristics are more gustatory then gravimetric then colorimetric then olfactory. These features are more observed during the rainy season. The appearance, taste and odor of drinking water must be acceptable to the consumer . because some substances of health concern have effects on the taste, odor or appearance of drinking water that would normally result in the water being released at concentrations significantly lower than those of health concern [24] . Indeed, groundwater undergoes seasonal variations. he deterioration in drinking water quality during the rainy season poses a serious public health risk for both untreated groundwater and commercially packaged water, highlighting the need to address monitoring gaps and quality control[25]. Contamination was significantly higher in the rainy season than in the dry season ($P < 0.05$) with 51.8% of water samples in the rainy season and 27.3% in the dry season, not meeting the guidelines from the World Health Organization and the Ghana Standard Authority on fecal coliform concentrations in drinking water sources[26]. The proportion of the population exposed to the risk of fecal contamination during the rainy season was 41.5% compared to 33.1% during the dry season [27] these changes observed by differences in contaminant levels between wet and dry seasons. are both chemical, physical and microbiological [28].

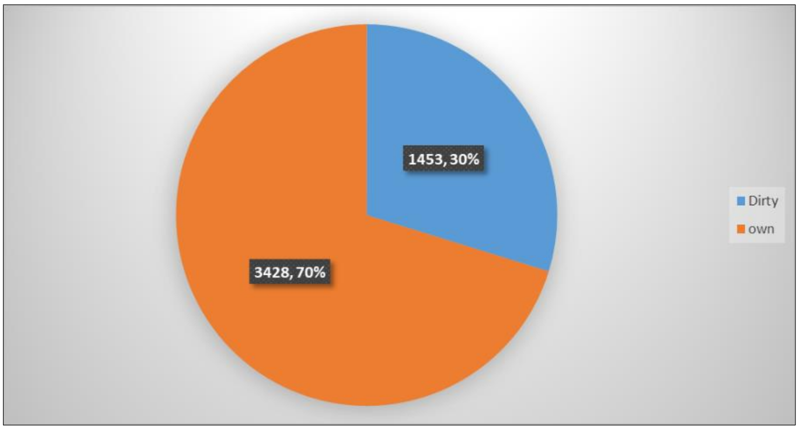

Figure 3 The appearance of the return of public tap water after cut-off

Seventy percent of public water users recognize that the appearance of the water when it returns after a cutoff is clean, and 30% note that it is dirty. The return of dirty water after cutting is an indicator of the deterioration of the pipe structure which allows residual water to infiltrate during cutting due to the reduction in pressure. This situation is favorable to water contamination.

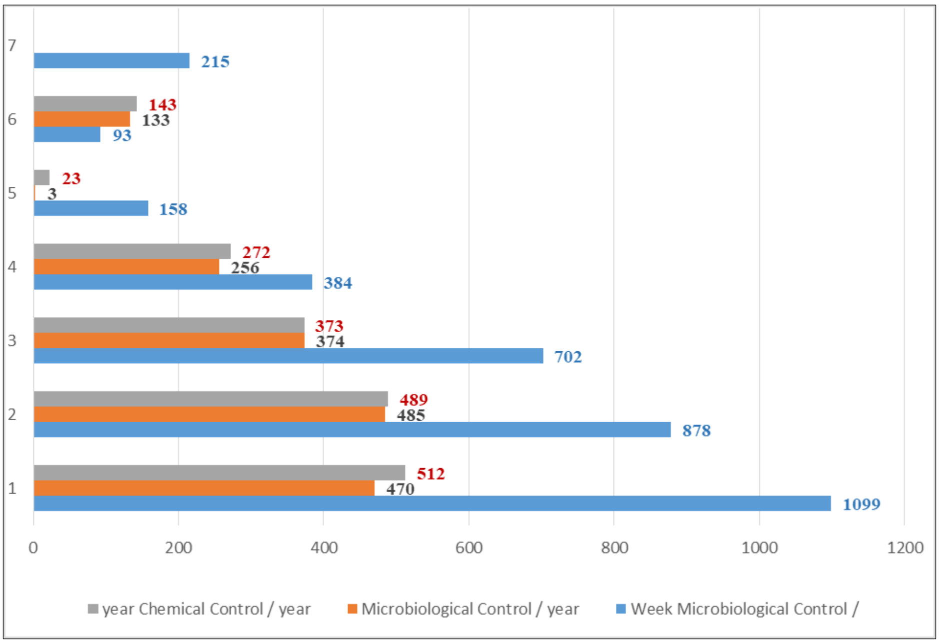

Figure 4 Physico-chemical and microbiological control of tap water and frequency of cuts for public supply

Overall, it is interesting to note that few households, i.e. a fifth of households, carry out physicochemical and microbiological monitoring of their water and that the majority of cut-off frequencies are one cut per week on average. But some households, i.e. 215, experience power cuts almost every day of the week. in fact, these controls are not only a guarantee of water quality by preventing contamination and the risk of nutrients (NH_4^+, NO_2^-, NO_3^- and PO_4^{3-}), COD , BOD_5, coliforms and potentially toxic elements (PTE) of As, Cd, Ni, Hg, Cu, Pb, Zn and Cr[29], but also, they prevent corrosion of microbial origin is a contributor potential for sporadic failures of galvanized steel systems containing water[30,31]. Management strategies should consider microbial control as a means of preventing the transmission of potentially pathogenic germs, but also for the prevention of corrosion in these systems using galvanized pipe networks.

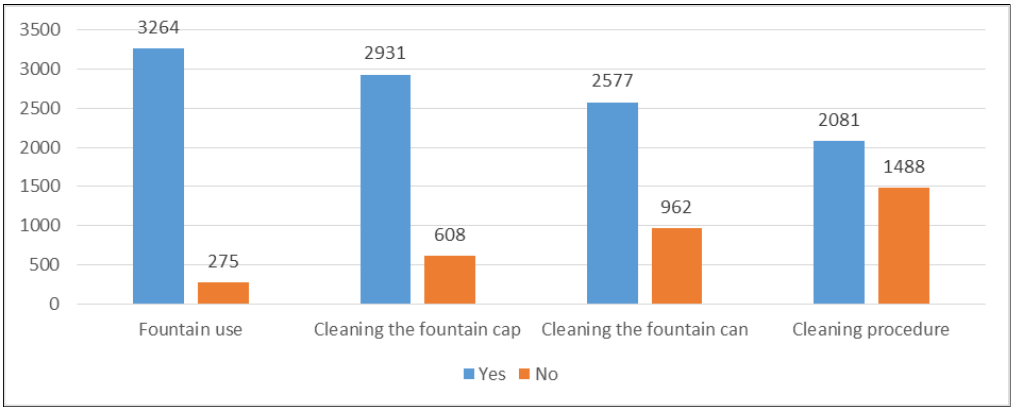

Figure 5 Distribution of households using water distribution fountains and whether they maintain them

Most households use water distribution fountains, i.e. 3264 cases or 92.22%, of which 58.8% or 2081 cases claim to know the fountain maintenance procedure, 82.82% or 2951 cases clean the cap before use. use of water and 2577 cases or 72.81% clean the entire container before using water.

The use of different sources to obtain water for human consumption instead of tap water or bottled water has continued to grow[32]. Their use provides an alternative to bottled water, overcoming and even eliminating the drawbacks that worsen the environmental impact of these products, such as the elimination of container materials (e.g., plastic)[33]. But refillable water dispensers are subject to extrinsic bacterial contamination that can transmit potentially pathogenic microorganisms; Bacteria present in the air or water can form an adherent biofilm inside water pipes, which can increase the risk of water contamination [34]. The term “biofilm” describes a growth pattern in which opportunistic pathogens that can harm human health [35], thrive immersed in a fluid and aggregate into a self-produced extracellular polymeric substance [36]. Therefore, bacteria growing in biofilms are more resistant to antimicrobial agents than planktonic cells of the same species [37]. Thus, to avoid contamination and the formation of biofilm and guarantee satisfactory quality of the water produced by the distributors, different disinfection procedures are applied [38,39] which unfortunately are not present in 41.92% of cases i.e. 1488 households and even households in possession of the procedure, the latter does not refer to the guidelines in the matter and what is more, is invalid.

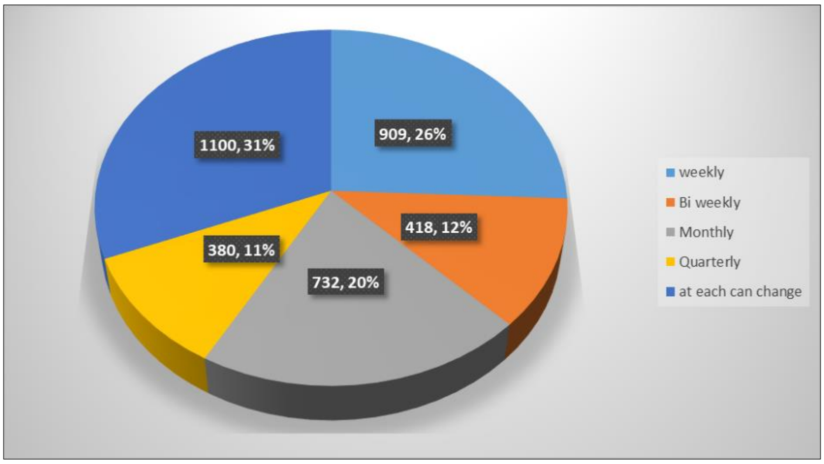

Figure 6 Distribution of maintenance frequency of water distribution fountains

Thirty-seven percent of fountain users admit to maintaining them weekly, thirty of them do it monthly and seventeen and sixteen do it twice weekly and quarterly respectively. following the need to have a valid disinfection procedure, which in this case is non-existent, the maintenance frequency in Figure 6 is thus random

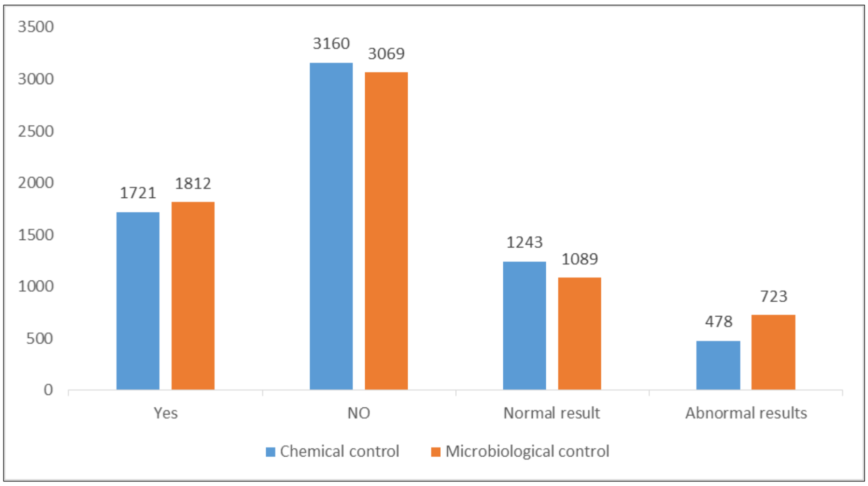

Figure 7 Control of the physicochemical and microbiological quality of fountain water

The control of the physicochemical and microbiological quality of fountain water was carried out respectively in 1721 and 1812 households, i.e. 35.25% and 37.12% of cases, in accordance with laboratory results. It is also important to note that when analyzing the results that the rate of positivity or declaration of water unfit for consumption is quite high, it is 72.22% or 1243 samples declared unfit for consumption out of a total of 1721 having undergone an analysis chemical and 63.27% or 1089 out of 1812 for microbiological analyses. These results sufficiently demonstrate that the internal pipes of water dispensers are loaded with microbes and chemical substances harmful to human health and require immediate disinfection. And when examining the fountains, we already observed in the main tank the presence of dust deposits, this situation is explained by the fact that in practice, when replacing the water cans, most often, the container's receiving receptacle remains open, allowing dust and other aerosols to settle there without difficulty. So whatever the hygiene provided to the cap before putting the can in place, contamination already occurs from inside the fountain through the formation of biofilm...

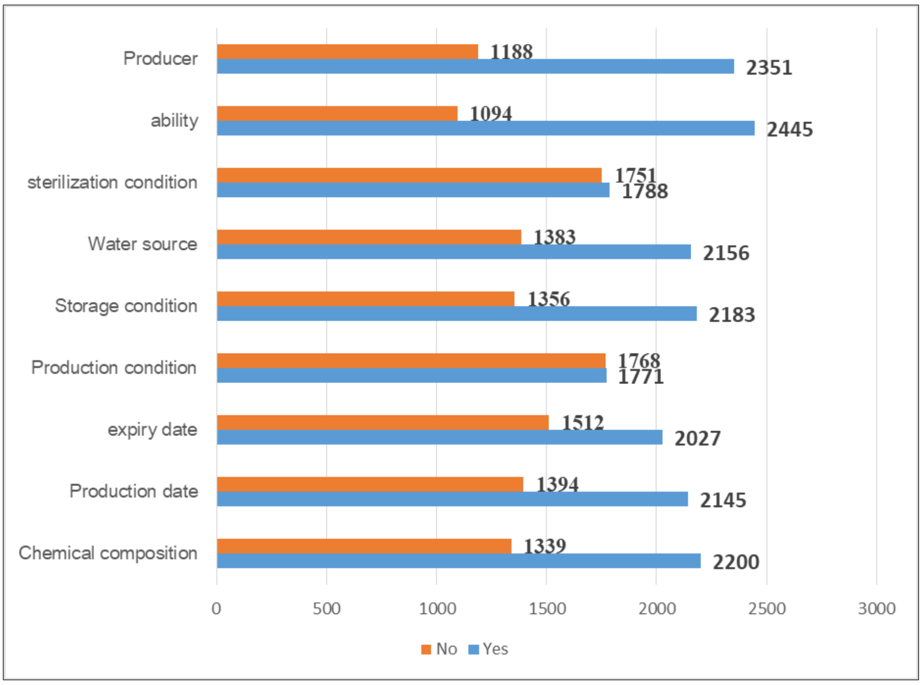

Figure 8 Information on the labeling of fountain water cans

Regarding the information provided on the labeling of water cans for fountains, the chemical composition is indicated in 62.16% of cases, The production date in 60.61%, The expiration date in 57 .27%, production and conservation conditions, respectively in 50.04% and 61.62%, 66.92% for the water source, 50.52% for the sterilization method, 69.08% for capacity and finally 66.43% for the identification of the producer. As in our previous study, brands provide nothing on their labels other than advertising information. Most brands did not meet WHO standards in terms of the list of required parameters and in terms of quantities per parameter assessed.[40]

3 Conclusion

This study documented the state of drinking water quality and poor sanitation system. Drinking water comes mainly from surface and underground aquifers near rivers or canals. And it must be free of color, turbidity, odor, and microbes. It should be aesthetically pleasing. The quality of surface water is decreasing rapidly due, on the one hand, to the addition of raw municipal and industrial effluents and agricultural runoff to water resources and on the other hand to the quality of the conveyance network according to whether public islands or a manual or industrial drilling system or even the quality and nature of the distribution pipes and the handling of fountains.

The observation is such that in Lubumbashi, the population consumes poor quality water as a result of the obsolescence of the public distribution network due to the use of oxidized galvanized pipes, the private network by manual drilling with shallow wells and including the water undergoes environmental and seasonal variations, or by industrial drilling network connected to PCV pipes on the surface which are exposed to the sun and therefore the heating produces allergens. Also the use of water distribution fountains leaves something to be desired because they are not or poorly maintained, thus leaving doubt about the quality of the water dispensed.

The results drew attention to the need to raise awareness among the population on the proper use of different systems according to standards to guarantee the quality of drinking water.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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