# The impact of the state of drinking water supply networks on the quality of water intended for consumption

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**Abstract** The suitability of drinking water for drinking depends not only on the source and purification system, but also on the quality of the water supply facilities. In fact, the quality of drinking water is significantly deteriorating due to the dilapidated state and lack of maintenance of drinking water supply networks. Most of the drinking water supply networks in different cities are aging. Despite the efforts made by the company responsible for the purification and distribution of water to make the water suitable for drinking, the water in consumers' taps is often colored, has an unpleasant taste and settles after collection. As a result, people are concerned about the suitability of tap water for drinking, and some turn to alternative sources of drinking water of unknown quality. In order to determine the factors responsible for the deterioration of the color and taste of water, as well as the most affected areas of the network, diagnostics of the network equipment were carried out. Water samples taken from the network were analyzed for color and turbidity. Diagnostics showed that most of the equipment (suction cups, valves, drains and fire hydrants) are outdated and irregularly maintained. The analyses show that water is more colored in cast iron and PVC pipes than in asbestos-cement pipes. The color values in the network vary from 0 to 27 UVC for asbestos-cement pipes, from 15 to 56 UCV for ductile iron pipes and from 11 to 102 UCV for PVC pipes. On the other hand, the turbidity values vary from 8.02 to 3.32 NTU for ductile iron pipes, from 8.51 to 16.98 NTU for asbestos-cement pipes and from 0.9 to 6.98 NTU for PVC pipes. Old cast iron pipes release iron ions when in contact with water, which deteriorates their color. Old cast iron pipes release iron ions into the water, which deteriorates its color. High color values observed near drains are believed to be due to irregular network maintenance. In fact, after network maintenance, a decrease in turbidity of 2% to 73% is observed, while for color, this figure varies from 5% to 72%. In short, network aging and irregular maintenance contribute significantly to the deterioration of water quality.

**Keywords:** Pipe, Water Supply Network, Drinking Water.

## 1. Introduction

Water is a natural resource essential for life and sustainable socio-economic development. The quality of water to meet different needs varies from one use to another. Water quality can be degraded by anthropogenic activities such as the use of fertilizers, phytosanitary products, chemicals and assimilated products and industrial effluents. Thus, this deterioration in drinking water quality can affect human health. In addition, the aging and lack of maintenance of drinking water supply networks does not come without consequences for the quality of tap water, while optimal management of drinking water supply networks requires supplying consumers with water that meets potability and quality standards, at a lower cost and without interruption in service. The phenomenon of obsolescence has affected most drinking water networks. In fact, these networks usually exist from the year they were put into operation and rarely undergo a regular renewal program, except in cases of pipe bursts. This can lead to the spread of faults in the network and have a negative impact on the health of consumers. Network faults usually manifest themselves in leaks, breaks, changes in water colour, pressure drops and hydraulic power in the network. Despite the efforts of the company responsible for water treatment and distribution to make the water suitable for drinking, the water in consumers' taps is often coloured, has an unpleasant taste and settles after collection in a container. Consumers of drinking water in the community are afraid of the colour and taste of tap water, so much so that some of the population turns to alternative sources of water, the quality of which for direct consumption is still unknown. To address these issues, this study was initiated to determine the impact of the water supply network on the quality of drinking water. The study will be conducted in two stages. First, a physical diagnostics of the network equipment will be carried out. Secondly, and finally, an analysis of the color and turbidity of water samples taken from the network was carried out.

**1.1. Field Equipment**

Equipment used in the field included: a Garmin etrex 10 handheld GPS navigator for determining geographic coordinates; a camera for taking photographs; survey sheets for conducting surveys; 1 liter (L) bottles for collecting water samples in the network; a cooler for storing water samples; a beaker for collecting water samples and glass tubes for on-site analysis.

**1.2. Laboratory Equipment**

The following equipment was used in the laboratory: HACH 2100Q nephelometer for measuring turbidity in water samples taken from the network; HACH DR 1900 spectrophotometer for measuring color of water samples taken from the network. PAleontological STatistics (PAST) 3.20, Autocad 2017 and ArcGIS 10.4.1 were used for data processing.

## 2. Main part

### 2.1 Physical diagnostics of the network

The physical diagnostics of various objects of the drinking water supply network included a detailed visual assessment of the condition, operation and performance of the equipment used for the transportation and distribution of drinking water. This includes tanks, pumping stations, pipes, valves, meters, water purification devices.

In addition, during the physical diagnostics, the geographic coordinates of various network equipment were collected to create a database.

### 2.2 Sampling

The samples were then collected in 1-liter plastic bottles and stored in a cooler with ice. Samples were taken from various types of materials that made up the entire network, as well as from fire hydrants and outlets before and after maintenance work.

## 3 Results

### 3.1 Physical diagnostics

#### 3.1.1 Diagnostics of suckers

All drinking water networks consist of pipes that transport water from the source to the consumer's tap. During this process, air pockets can form and remain in the pipes. The main function of the suction cup in the drinking water network is to continuously pump out air pockets that have entered the pipes. Physical diagnostics of the suction cups not only identified all the suction cups in the drinking water network, but also checked their physical operating condition.

Diagnostics show that 67% of air valves in the network are in good condition (BE), 28% are in faulty condition and 5% are in poor condition.

#### 3.1.2. Fire Hydrant Diagnosis

The diagnostic results show that 37% of fire hydrants are faulty, 32% are located in high pressure zones, 21% are in low pressure zones and 10% are not serviced because they are located in areas that are difficult to access by the network.

#### 3.1.3. Drain Diagnostics

The diagnostics showed that: 56% of drains are treated and in good condition, 13% of drains are inaccessible, 5% of drains are located in low pressure areas, 2% are faulty.

### 3.2 Qualitative Diagnosis

The qualitative diagnostics of water samples taken from the Daloa drinking water network mainly concerns two parameters that cause concern to the population, such as colour and turbidity.

#### 3.2.1 Turbidity

In the water supply network, which is mainly composed of cast iron pipes, the recorded turbidity values are in line with the World Health Organization (WHO) guideline values, except for places such as the traditional treatment plant, compact plant.

In the distribution network:

- Turbidity values recorded on cast iron pipes do not exceed WHO recommended values;
- High turbidity values observed at the reservoir are due to mixing of waters, and at Radio Tkhrato due to the fact that this point is located close to the discharge.
- For asbestos-cement pipes, the recorded values do not correspond to WHO recommended values.

### 3.3 Water Supply System Maintenance

Maintaining a drinking water network involves regularly cleaning pipes and other network equipment. Maintaining a drinking water network helps ensure water availability and provides consumers with better quality water. It minimizes service interruptions and contamination risks, and ensures that hydrants and fire hydrants are working properly.

## 4 Discussion

Physical diagnostics show that the Daloa water network includes some faulty equipment, which prevents maintenance work from being carried out at certain points in the network. The lack of maintenance is the source of sludge accumulation in the network, which is a potential source of discoloration and increased turbidity in the water network.

A common feature observed between the water from the treatment plant and the water passing through the supply pipes is high levels of color and turbidity. In fact, a malfunction of some pneumatic valves that discharge the settled flakes from the settling tank may lead to their re-suspension and clogging of the filters. Consequently, a deterioration in the quality of the water at the inlet to the network due to a decrease in the performance of the filtration system will be a consequence of the observed malfunctions. Secondly, failure to pump out will contribute to the accumulation of sludge in the water supply network. In addition, the continuous discharge of sludge into the water supply network along its entire length and the physical and chemical reactions that can occur between the connecting parts of the pipes (cast iron or steel) contribute to an increase in the color and turbidity of the water.

The main cause of water quality deterioration in metal pipes such as cast iron is pipe corrosion. In fact, corrosion reactions cause metal ions to be released into the water, which causes iron ions to precipitate, which can puncture the walls of ferrous pipes, causing scale formation (reduction in diameter). In addition, problems with red water, metallic taste, and increased concentrations of dissolved metals are all consequences of pipe corrosion.

Asbestos cement pipes are not subject to corrosion problems; this is a significant advantage over cast iron metal pipes. However, when in contact with water, the material (asbestos cement) releases calcium hydroxide $Ca(OH)2$, which is said to have a carcinogenic effect on the health of consumers. This is reflected in high turbidity values and low color values. This can lead to increased alkalinity, calcium content and the release of magnesium, silicon and hydroxide from asbestos ($Mg_3Si_2O_5(OH)_4$). However, near pumping stations, the accumulation of sludge in the pipes increases the color and turbidity of the water.

PVC pipes are not as susceptible to corrosion as asbestos-cement pipes. The increase in turbidity and color in PVC pipes can be explained by the lack of purging in the network and the transit of water from one type of material to another. In PVC pipes, corrosion of cast iron or steel fittings and the transit of water from cast iron to PVC pipes increase the color and turbidity of the water, as well as the concentration of iron ions. The increase in organoleptic indicators can then become a source of taste development in the network.

In the water supply network, the high turbidity values are thought to be due to the accumulation of dirt after a long period of residence on the site. The discrepancy between the turbidity values of the cast iron pipes and those observed in the water supply network may be due to the fact that the water supply network is quite new, while the distribution network, which is quite old, may be affected by corrosion of the pipes.

**5. Conclusion**

In this study, we analyzed the factors that degrade the physical and organoleptic characteristics of the drinking water supply network in a community. Samples were analyzed for two physicochemical parameters: turbidity and color. The results showed that color and turbidity did not meet the 2017 WHO guideline values for either the supply or distribution network. After network maintenance, the reduction rate for turbidity ranged from 2% to 73%, while for color, the rate ranged from 5% to 72%. Lack of network maintenance leads to sludge accumulation in the network and is one of the main causes of color changes, taste and sediment in consumer tap water. It appears that color and turbidity are the determining factors for water quality deterioration in the drinking water supply network.

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