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Theme

Assessment of the physicochemical and bacteriological quality of groundwater in the Bouira region

Supported on:06/27/2023 **Before the jury composed of:**

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Dedication

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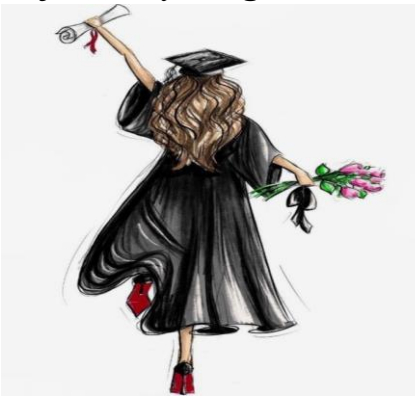

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Abreviations list

ABC: Reduced bacteriological analysis

ABR: Complete bacteriological analysis

ACC: Complete chemical analysis

ACR: Reduced chemical analysis

ADE: Algerian waters

BCPL: Lactose broth with bromocresol purple

C°: Degree Celsius

$CaCO_3$: Calcium carbonate

THIS : Electrical conductivity

DPD1: Diethyl-p-phenylenediamine 1(free chlorine)

DPD4: Diethyl-p-phenylenediamine 4(total chlorine)

E.coli*:Escherichia coli*

EDTA: Ethylene Diamine Tetraacetic Acid

H_3PO4: Ortho phosphoric acid

MY: Suspended matter

MTH: Water-borne diseases

NPP: Most likely number

NTU: Turbidity Nephelometry Units

WHO: World Health Organization

pH: Hydrogen Potential

T:Temperature

AT: Simple alkalimetric titer

TAC: Complete alkalimetric titer

TDS: Dissolved salt rate

TGEA: Tryptone glucose agar with yeast extract

TH:hydrotimetric title

CPU: Color unit

CFU: Colony Forming Unit

µS/cm: Siemens micro on centimeter

Introduction

Introduction

Water is essential for the survival of living beings. Its availability in sufficient quantity and good quality is crucial for maintaining health. However, in certain circumstances, it can also be a vector for the spread of diseases such as cholera, diarrhea and typhoid fever. Rapid population growth and urbanization are causing environmental disruptions, including contamination from industrialization, excessive use of pesticides and fertilizers, and lack of awareness about environmental conservation. These activities produce pollutants that can alter the quality of aquatic environments (Lalanne, 2012; Kahoul and Touhami, 2014; Kahoul et al., 2014). The control of drinking water is essential for the prevention of water-borne diseases and must meet rigorous quality standards, both physicochemically and bacteriologically, for safe use for food and hygiene purposes (Coulibaly, 2005; Hounsounou et al., 2018). In Algeria, drinking water comes from underground or surface sources. The majority of Algerians consume drinking water, generally from surface water reservoirs, treated in stations that meet Algerian drinking standards (Kahoul and Touhami, 2014; Ouahchia et al., 2015).

However, water quality can deteriorate as it travels from treatment plants to consumers' taps.

As part of a study aimed at controlling the quality of water intended for consumption in a given city, we evaluated the physicochemical and bacteriological quality of several samples taken from different locations.

Our study aims to evaluate the bacteriological and physicochemical quality of groundwater in the wilaya of Bouira. Our study is structured in two distinct parts:

- A bibliographical part comprising two chapters: the first chapter covers generalities on water, while the second focuses on the different water sources.
- An experimental part: it begins with a presentation of the ADE Bouira (Algerian Des Eaux) unit, then addresses sampling and the methodology used. Afterwards, we begin the results and discussions. In conclusion, we close our work with a summary of the main results.

Bibliography section

Chapter 1

General

Water represents the primordial vital source, being the fundamental component of all forms of life, each cell bathing in its aqueous environment. It plays a crucial role in regulating intracellular and extracellular concentrations, thus facilitating cellular exchanges that promote the growth and development of the organism.**(Hubert and Marin, 2001).**

In reality, all living beings evolve on a planet often nicknamed the "blue planet", distinguished from other planets in the solar system by its abundance of water. Water supply has become a vital necessity in all areas of life, particularly due to global population growth and improved standards of living (Luna and Kenneth, 1972).

1. Definition of water

Water is widely distributed in nature, occurring as a clear liquid, devoid of odor and taste, with a neutral pH, and acting as an essential solvent for the life of most living organisms (Bernard , 2007).

According to WHO (World Health Organization) standards, safe drinking water is water that is safe to drink, free from any pathogens such as bacteria, viruses and parasites that pose a significant risk to human health (Report on monitoring the quality of drinking water in Algeria, 2008).

2. Importance of water

2.1 Importance for humans and animals

Water constitutes the main element of the human body. On average, an adult is about 65% water. The human body continually eliminates water. After digestion, most water is absorbed through the walls of the intestine and then transported by blood and lymph throughout the body, including to the kidneys, skin, and lungs; it is then eliminated by various means (urine, perspiration, respiration). Thus, every day, humans must meet their water needs by drinking but also by consuming foods rich in water. To maintain good health, water losses must be compensated by intake. In fact, thirst is a mechanism by which the body signals its state of dehydration (Balderacchi, 2009).

2.2 Importance for plants

Plants are mainly composed of water, a crucial element for their survival and optimal functioning, by transporting the nutrients and mineral substances necessary for the plant for its growth and nutrition. This process is illustrated by diffusion, whereby the plant absorbs water and minerals from the soil to form its raw sap. This sap, once enriched with essential organic substances thanks to photosynthesis, descends to support the normal development of the plant and constitute reserves for its future reproduction. Continuous exchanges of water with the environment, such as transpiration and guttation, also participate in the thermal regulation and water balance of the plant (**Hopkins, 2003).**

3. Water cycle

Water is involved in a continuous natural cycle, constantly moving between the earth and the atmosphere (Musy and Higy, 2004).

The hydrological cycle (Figure 1) is generated by the constant and continuous evaporation of oceans, rivers, and lakes, as well as by the evapotranspiration of plants and seas (Kirkpatrick and Fleming 2008). Cold air causes water vapor at altitude to condense, transforming the vapor into small droplets that form clouds. These clouds are then carried across the sky by the winds. In the atmosphere, cloud condensation occurs around dust particles, giving rise to precipitation in the form of rain or snow, under the influence of complex weather phenomena, including winds and temperature variations (Musy et Higy, 2004).

Water runs off and penetrates the ground, seeping to fill groundwater. By crossing the different layers of the soil, it gets rid of most of the impurities it had accumulated along the way (Musy and Higy, 2004). Groundwater also circulates, with some reaching the oceans directly while the remainder feeds rivers from their sources or through tributary rivers (Kirkpatrick and Fleming, 2008). Finally, water can return to the liquid state in the atmosphere through the transpiration of plants, which thus release part of the water contained in the soil while retaining another part of the rainwater in their leaves. (Musy and Higy, 2004).

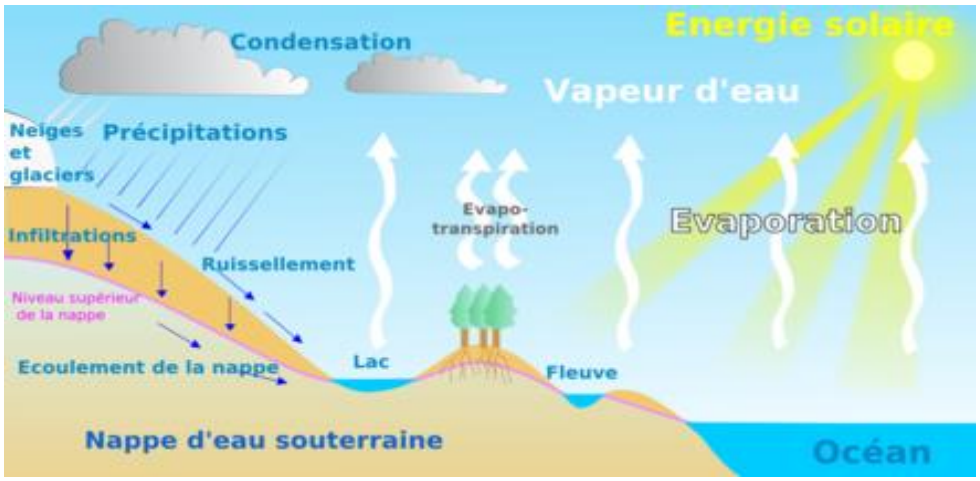


Figure1: The different stages of the water cycle (Kassou and Kacimi, 2010).

4. Water in Algeria

In a semi-arid and arid context such as that of Algeria, access to water is often limited and characterized by great irregularity and a specific location. In the Saharan zones, the beds of the wadis contain some groundwater which is generally saline, such as Ghir, M'Zab, Saoura, etc. Apart from these, the available aquifers are mainly deep, semi-fossil or fossil and remain largely underexploited.

In northern Algeria, the main source of water is runoff after rainfall. The wadi regime is characterized by periods where the bed, poorly defined, is crossed by a thin trickle of water for months, even years, to suddenly flow up to 5000 cubic meters per second, thus causing catastrophic floods. These floods, spreading from west to east, gradually extending to the Monts de Tlemcen, the northern slope of the Ouarsenis, the Kabylie massif, the north of Constantinois and finally the Aurès massif (Arrus, 1962).

Chapter 11

Water sources

Most of the water on earth is found in oceans and seas. About 97% of this water is salty. In contrast, less than 3% of the water on Earth is fresh water, two-thirds of which is frozen in polar ice caps and glaciers. The fresh water available in groundwater, lakes, rivers, streams, ponds and marshes represents only less than 1% of the total water available on the planet (CIR, 1983).

1. Natural sources of water

The different natural origins of water mainly include rainwater, seawater, surface water and groundwater. Each source has specific characteristics that result from the interaction between water and its environment.

1.1 Rainwater

Rainwater is of good quality for human consumption due to its softness, attributable to the presence of oxygen and nitrogen and the absence of dissolved salts such as magnesium and calcium. However, in industrialized areas, they can be contaminated by atmospheric particles. Furthermore, due to the irregular distribution of precipitation over time and the challenges associated with its collection, few municipalities use this water source (Desjardins, 1997; OFEFP, 2003).

1.2 Sea waters

Seawater is only used as a source of raw water when fresh water is not available. They are characterized by high salinity, generally varying between 33,000 and 37,000 mg/L, which also qualifies them as "brackish waters". Their use is made difficult, mainly due to the high costs associated with their processing (Boeglin, 2009).

1.3 Surface water

Surface water refers to water that circulates or is stored on the land surface. They come either from emerging groundwater or from runoff water (rivers, dams, ponds) (Degrement, 2005).

This water requires treatment in several stages before being used for human consumption and domestic needs, because it is not drinkable in its raw state. Furthermore, so that they can be used to supply populations, it is crucial to prevent soil erosion, maintain adequate sanitary conditions and prevent accidental and chronic pollution (Molinie, 2009).

1.4 Groundwater

Groundwater (Figure 2) refers to water below the ground surface, filling either fractures in the underlying rock or pores in granular materials such as sand and gravel. Unlike surface water,

groundwater does not form visible watercourses but circulates at depth through underground geological formations.

The level at which rocks or sediments are saturated with groundwater is called the water table. There is also water above the water table, in the unsaturated zone, such as soil water, but this water is generally not exploited by humans (Myrand, 2008).

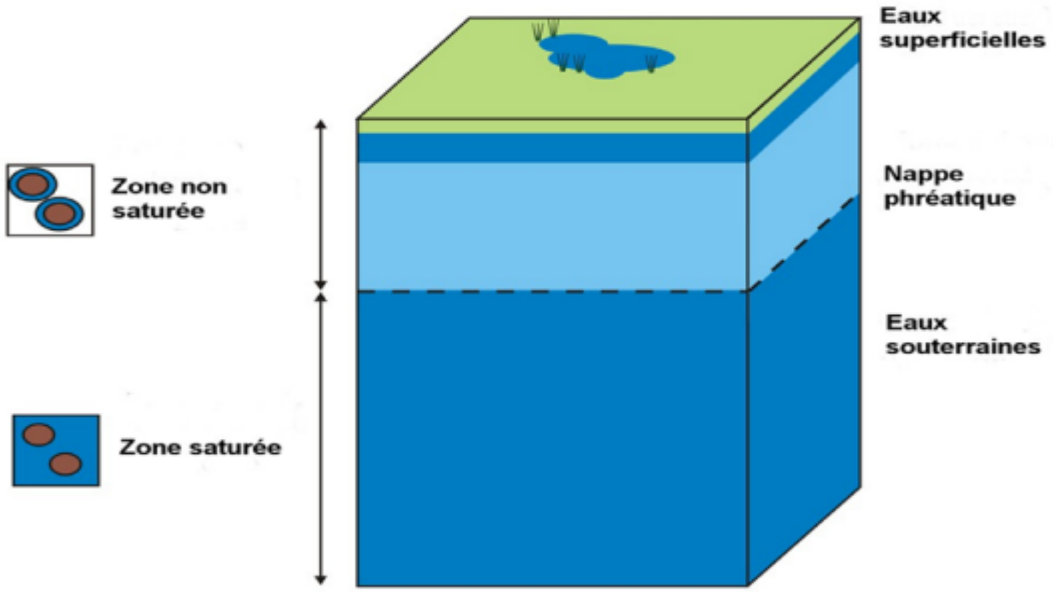


Figure2: Presentation of groundwater (Myrand,2008).

2. The origins of groundwater

2.1 Meteoric waters

Most groundwater originates from precipitation such as rain and snow, which then seeps underground. In large aquifers, these waters can also come from periods when the climate was different, making them potential indicators of paleoclimates (Renard, 2002).

2.2 Connate waters

Groundwater located deep in the Earth's crust, generally from 1 to 2 km depth, derives from reservoirs of meteoric waters that have reacted with surrounding rocks. Often salty, these waters can contribute to the hydrology of recently buried geological formations or remain trapped in rocks

with low permeability, where not all the water has been expelled. They can also be present since the formation of the rock (Renard, 2002).

2.3 Juvenile waters

Juvenile waters come directly from the depths of the Earth's mantle. They generally leave this compartment during the degassing of terrestrial volcanoes, the crystallization of magma or the eruptions of hydrothermal sources (Renard, 2002).

3. Groundwater parameters

The quality of drinking water depends on its organoleptic, physicochemical and bacteriological characteristics. It is crucial to measure or estimate these parameters to anticipate the quality of water intended for consumption.

3.1 Organoleptic parameters

Organoleptic factors often constitute warning factors for pollution, but they do not necessarily guarantee a health risk (Rodier, 2005). These criteria relate to the sensory characteristics of water such as its color, flavor, odor and transparency (Goita, 2014).

- **The colour**

Water color is usually caused by the presence of suspended colored organic matter, metals, or tinted industrial waste. An unusual alteration of this color is often a sign of pollution of the source or network (Luc and Lagardette, 2009; Savary, 2010). The true color of water is determined solely by dissolved substances once turbidity has been removed (Savary, 2010).

- **The smell**

The presence of an odor generally indicates pollution or the presence of decomposing organic matter. Smell can be defined as the set of sensations perceived by the olfactory organ when it detects certain volatile substances. The quality of this specific sensation depends on each substance (Rodier, 2005).

- **The taste**

Flavor represents the taste of water, but it does not always reflect its quality. However, any change in flavor may indicate degradation (Bordet, 2007).

- **Turbidity**

Water turbidity reflects the presence of various suspended particles, such as clay, silt, organic, colloidal particles, plankton and microscopic organisms, which give the water a cloudy appearance.

It can result from deposits in pipes or disturbances linked to corrosion or water treatment (Savary, 2010).

3.2 Physico-chemical parameters

The physicochemical quality of water makes it possible to determine the presence and extent of pollution, based on a set of parameters defined by reference values. This quality is evaluated using several criteria (Rodier et al.,1996). Among these parameters, the following can be distinguished:

- **Temperature (T°C)**

Water temperature plays an essential role in the aquatic ecosystem because it influences the physical, chemical and biological reactions that take place there (Nouayti et al., 2015).

- **Hydrogen potential (pH)**

The pH of water indicates its acidic or alkaline character. It is determined by the concentration of H+ and OH- ions in water and influences numerous physicochemical balances (Arouya, 2011).

- **Electrical conductivity (EC)**

Electrical conductivity measures the ability of water to conduct an electric current, which depends on its content of dissolved substances, its ionization capacity, ionic charge, temperature and mobility. It is also used to assess the degree of mineralization of water. High conductivity may indicate unusual pH values or high salinity (Kouidri, 2006; Nouayti et al., 2015; Tchadanaye et al., 2016).

- **Hardness (TH)**

Hardness, also called hydrotimetric titer (TH), which is due to various dissolved versatile metal ions, mainly calcium (Ca^{2+}) and magnesium (Mg^{2+}) salts (Malloum et al, 2015).

- **Chloride (Cl^-)**

Chlorides are commonly found in nature, mainly in the form of salts such as sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$) chloride (SEVESC, 2013). Due to their non-adsorbed nature by geological formations, chloride ions remain very mobile and have a low propensity to bind with other chemical elements. This mobility makes it a sensitive indicator of pollution. Chloride concentrations in waters vary considerably and are mainly influenced by the geology of the regions crossed. However, their presence can pose a problem due to the unpleasant flavor they impart to water, especially above 250 mg/l (Rodier et al., 2005).

- **Salinity**

Salinity represents the quantity of dissolved salts, expressed in (g/kg). An ionic compound or crystalline ionic solid is made up of cations (positively charged) and anions (negatively charged) organized regularly in space. In general, ionic crystals are electrically neutral (Gaujous, 1985).

- **Suspended matter (MES)**

They are very fine solid particles, often visible to the naked eye, which normally do not dissolve or appear in colloidal form. They contribute to water turbidity by limiting light penetration, reducing dissolved oxygen content and disrupting the development of aquatic life. These particles are linked to turbidity and their initial measurement gives a preliminary indication of the quantity of colloidal material of mineral or organic origin. Measuring deMES makes it possible to estimate the quantity of solid particles suspended in natural or waste water (Bara, 2016).

- **Dissolved oxygen**

The concentration of oxygen depends on various factors such as temperature, atmospheric pressure, salinity and the origin of the water. Surface waters often have relatively high oxygen concentrations, close to saturation, while deep waters typically contain a few milligrams per liter. It is expressed in mg/l (Rodier, 1984).

- **Iron (Fe+2)**

A mineral impurity with no appreciable effect on health, it can cause discoloration and cause deposits in networks, sometimes leading to corrosion. Furthermore, it affects organoleptic parameters like other metals.

In surface waters, iron is generally found in an oxidized and precipitated state; it is therefore eliminated by classic clarification treatments (Degrement, 1952).

- **Manganese (Mn+2)**

This metal can cause discoloration and contribute to the formation of deposits in the networks. It influences the sensory characteristics of water, just like other metals. In surface waters, manganese is generally present in oxidized and precipitated form, which allows its elimination by conventional clarification methods (Degrement, 2005).

- **Nitrates (NO-3)**

Ions naturally present in the environment, resulting from the degradation of organic matter. They are among the most widespread chemical contaminants in water supplies worldwide. Their is often linked to a form of pollution of human origin. Due to their high solubility in water, nitrates can move easily through the soil. Over time, they can accumulate in groundwater, which is then exploited as a source of drinking water (Hailu, 2017).

- **Nitrites (NO-2)**

Nitrites are widely found in soil, water and plants, but generally in low concentrations. They result either from partial oxidation of ammonia or from a reduction of nitrates. Additionally, they can come from poorly managed water treatment processes, such as problems with sand filters, activated carbon filters, or during biological nitrification-denitrification steps. However, a high concentration of nitrites is often associated with a deterioration of microbiological quality (Bouziani, 2000).

- **Ammonium (NH4+)**

Ammonium (NH4+) is a form of ammoniacal nitrogen present in water, which can convert into ammonia (NH3+), a toxic substance. Its presence in water is generally linked to a process of incomplete organic decomposition. Ammoniacal nitrogen can quickly transform into nitrites and nitrates through oxidation. However, the use of ammonia as a nitrogen source in water can pose challenges, as it requires increased chlorine consumption during disinfection processes (Chaden, 2014).

- **Phosphates (PO4)**

Phosphates are often associated with accelerating the eutrophication process in lakes and rivers. When they exceed standards, they are considered an indicator of fecal contamination, leading to proliferation of germs, as well as undesirable taste and coloring (Rodier, 2005).

3.3 Bacteriological parameters

The most important parameter for assessing the quality of drinking water is based on the presence of pollution indicator organisms, notably total germs and Coliforms. The latter are bacteria that normally inhabit the intestines of humans and animals. Among the indicator bacteria of fecal contamination, we find Coliforms, including Escherichia coli (E. coli), fecal Streptococci and sulphite-reducing Clostridium. They multiply rapidly, making them common indicators of fecal contamination (Ahonon, 2011).

- **Total germs**

The enumeration of aerobic mesophilic bacteria, or total germs, aims to evaluate the overall density of the bacterial population present in drinking water. This method is carried out at two different temperatures to take into account microorganisms preferential for cold, at 20 °C, as well as those favoring higher temperatures, at 37 °C. This provides a comprehensive view of overall water quality, although it does not identify specific sources of contamination (Ayed, 2016). Testing for total germs at 22°C and 37°C is crucial because some pathogens can cause infectious diseases in humans when ingested through contaminated water or food (Hamed et al., 2012) .

- **Total coliforms**

Total Coliforms have been used for a very long time as indicators of the microbiological quality of water, because their presence can be indirectly linked to contamination of fecal origin. Total Coliforms are defined as bacteria of bacillary form, Gram negative, aerobic or facultatively anaerobic, non-sporulating, oxidase negative, possessing the ß-galactosidase enzyme which allows them to ferment lactose at 35/37 °C with gas production in 48 hours. They are also capable of growing in the presence of bile salts or surfactants, and they are sensitive to chlorine (Leyla et al., 2002; Ayed, 2016).

- **Thermotolerant Coliforms**

Faecal coliforms, also known as thermo-tolerant coliforms, are a subgroup of total coliforms and have the ability to ferment lactose at a temperature of 44°C within 24 hours. Their presence may indicate the presence of enteropathogenic microorganisms, such as salmonella (Chevalier, 2003).

Escherichia coli (E. coli) is the species most commonly associated with this bacterial group, being the only indicator bacteria that clearly indicates contamination of animal or human fecal origin (Chevalier, 2003).

This group incubates at a temperature of 44°C. An example is E. coli, which produces indole from tryptophan, ferments lactose or mannitol with production of acid and gas. Generally, it cannot reproduce in aquatic environments, so their presence in water indicates recent fecal pollution (John et al., 2010).

- **Thermotolerant Streptococci**

They are characterized by their slightly oval, coccal shape and their Gram-positive staining. They are generally arranged in diplococci or chains, developing optimally at 37°C and producing lactic acid without gas, thus demonstrating a homo-fermentative character. This group is subdivided into two subgroups: Enterococcus and Streptococcus (John et al., 2010).

Their research is carried out at 37°C and concerns Gram-positive cocci, spherical or oval in shape, generally presenting in chains of varying length. They are neither sporulate, nor catalase, nor oxidase, and are normal inhabitants of the human body, not being considered pathogenic (Leyla et al., 2002).

They occur following old fecal contamination and can multiply in environments with a pH of up to 9.6. Therefore, these microorganisms can serve as indicators for pathogenic organisms with similar resistance to high pH (Seghir, 2008).

- **Sulphite-reducing Clostridium**

Gram-positive bacilli, typically measuring 4 to 6 µm in length and 1 to 2 µm in width. They produce spores, the most characteristic of which is Clostridium perfringens.

These microorganisms are part of the natural telluric flora and are also found in human and animal feces. Therefore, their presence does not make it possible to specifically attribute a fecal origin. The search for these indicators is often motivated by their ability to form spores, thus making them particularly resistant to disinfection processes (Gleeson and Gray, 1997).

4. The water pollution

Water pollution results from its contamination by various foreign elements such as microorganisms, chemicals, industrial waste, among others. These substances alter the quality of water, making it unsuitable for its various uses (Ramade, 1984).

This phenomenon can be defined as the deterioration of water by the elements it accumulates during its use, notably coming from chemical waste, industrial discharges and leaching of the soils crossed (Boeglin, 2001).

Water pollution is now a major environmental problem because water acts as an interface between air and soil. Water is considered polluted when a massive and lasting input of substances, more or less toxic, of natural or human origin, alters its balance. Human activity, whether industrial, urban or agricultural, generates a large quantity of polluting substances responsible for different types of pollution. These can be permanent, such as domestic discharges from a large city, periodic, or even accidental, such as spills of industrial or agricultural toxic products, or the washing of urban soils during heavy rains (Rodier, 2005).

4.1 Groundwater and surface water pollution

Surface water pollution is easily noticeable, immediately drawing attention to the risks involved and the measures to be taken to remedy them. On the other hand, groundwater pollution is less obvious, which generally leads to it being neglected. However, it represents an equally serious danger, because it affects resources of particularly valuable quality and reserve (Schoeller, 1975). This pollution constitutes a permanent threat to the depletion of water resources in the short term (Castany, 1982). The risks associated with groundwater pollution are linked to the contamination of groundwater and water sources through the infiltration of wastewater (Hélène, 2000)

4.2 The main water pollutants

- **Physical pollutants**

Physical pollutants are distinguished primarily by their industrial origin, with a secondary contribution from domestic sources. Among these pollutants, two categories can be identified: thermal pollutants and radioactive pollutants (Arouya, 2011).

➢ **Thermal pollutants**

Thermal pollution manifests itself through discharges of hot water, mainly emitted by the cooling systems of nuclear and power plants, leading to significant warming of the surrounding waters. This phenomenon alters various physical properties of water, such as a reduction in its density, and causes significant disturbances in aquatic ecosystems (Arouya, 2011; Mazzuoli, 2012).

➢ **Radioactive pollutants**

The main source of radioactive pollution lies in spills containing radioactive elements, notably from nuclear weapons explosions and waste from installations using atomic energy (Lefèvre and Andréassian, 2016).

- **Chemical pollutants**

Chemical pollution is probably the most widespread and diverse (Hartemann, 2013). It is mainly due to industrial discharges which introduce large quantities of chemical substances, thus disrupting the balance of aquatic ecosystems (Arouya, 2011). There are several types of pollutants depending on their nature:

➢ **Organic pollutants**

The most important and dangerous organic pollutants present in aquatic environments are pesticides, hydrocarbons and detergents (Arouya, 2011).

➢ **Inorganic pollutants**

Among the inorganic pollutants released in large quantities by industry, we find ore processing residues, electrolytic treatments, surface treatments, many of which contain heavy metals, sodium, nitrates, phosphates, etc., and are therefore very toxic (Arouya, 2011).

- **Microbiological pollutants**

The presence of microbiological pollutants in water is a major problem, with significant microbial and parasitic contamination. Many pathogens, such as bacteria, viruses and protozoa, can be present in water, often due to the discharge of human and animal feces.

This form of pollution is observed in various sources, including sewage treatment plants, hospital effluents, water from washing laundry and soiled equipment, as well as spills from many food industries (Feachem et al., 1983; Mazzuoli, 2012; Hartemann, 2013).

4.3 Risks linked to water pollution

Water plays an essential role in daily life, health and well-being, but it can also be a vector for many microorganisms such as bacteria, viruses and protozoa, which can live and proliferate there. In developing countries, where compliance with individual and collective hygiene standards is often lower, two main groups of water-borne pathologies are identified. It is important not to confuse them because of the different therapeutic and preventive measures associated with them:

• Diseases transmitted by contact with contaminated water or by vectors.

• Diseases linked to the consumption of water contaminated by pathogens (Huot, 2010).

The term "waterborne disease" or MTH (Transmissible Water Disease) refers to any disease caused by the ingestion of water contaminated by feces of human or animal origin, containing pathogenic microorganisms. These diseases include brucellosis, tuberculosis, typhoid fever and cholera, to name a few, which lead to the deaths of thousands of people worldwide each year (Huot, 2010).

Painting1: The main water-borne diseases and their pathogens. (Rodier, 2009).

Origin	**Diseases**	**Agents**
Bacterial origin	-Typhoid fever and paratyphoid -Bacillary dysentery -Cholera -Acute gastroenteritis and diarrhea - Pneumonia	-Salmonella typhi -Salmonella paratyphi A and B -Shiguellasp -Vibrio cholera -E.colienterotoximogenic, -Campylobacter jejuni, -Yerisinia enterocolitica -Salmonella sp -Legionella pneumophila
Viral origin	-Hepatitis A and E -Poliomyelitis -Acute gastroenteritis and diarrhea	-Hepatitis A and E viruses -Poliovirus -norwalk virus -Rota virus -Astrovirus -Calicivirus -Enterovirus

		-Adenovirus
Parasitic origin	- Amoebiasis - Gastroenteritis	-Entamoeba histolytica, -Giardia lamblia -Cryptospridium

5. Water treatment

Certain minimum characteristics are required so that they can be used for the production of drinking water which must itself satisfy the physicochemical and biological qualities.

The treatment of natural waters for the production of drinking water generally involves adjustments according to the quality parameters to be corrected. For groundwater of satisfactory quality, a simple chlorination process is generally sufficient (Guergazi and Achour, 2005). On the other hand, when the source is surface water and contains various chemical and biological pollutants, the process may require several steps, such as the removal of suspended matter, organic or mineral products, as well as micropollutants, depending on the initial quality of the raw water (Festy et al, 2003).

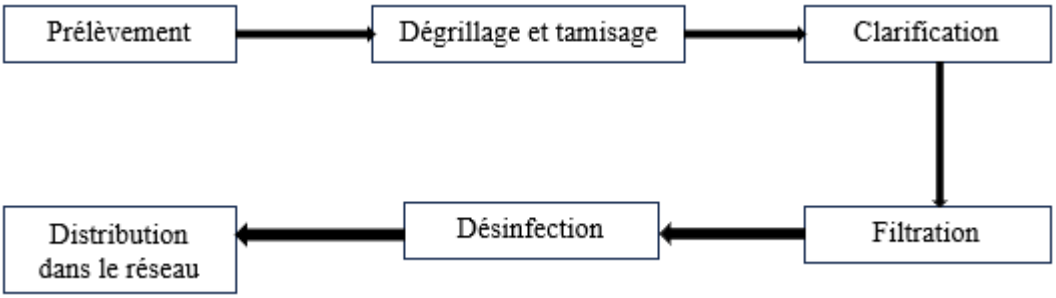


Figure 3: Diagram of the principle of water treatment (Moletta).

Some types of water contain trace amounts of micropollutants, such as pesticides or organic matter, requiring an additional process called "refining." For this, beds of activated carbon approximately 1 meter thick are used. They adsorb these unwanted molecules, thus eliminating the bad taste and odors of the water (Moletta).

6. Potability standards

What is drinking water? According to the World Health Organization (WHO, 1972), water intended for consumption must not contain any chemical substances or germs harmful to health. In addition, it must be as pleasant to drink as circumstances permit. This definition must be translated into terms allowing us to determine whether water is drinkable or not. This is the purpose of potability standards, a quantitative approach to the qualitative notion of potability. These standards will apply to a certain number of quantities deemed relevant in this area (Kouidri, 2006). (ANNEX I)

Practical side

Chapter 1

Material and method

1. Goal of the study

Our study aims to:

✓ To evaluate the physicochemical and bacteriological quality of groundwater intended for consumption in the Bouira region and define their potability.

✓ To compare the results obtained, then to local and international standards.

2. Presentation of the ADE unit

2.1. Definition of ADE

"L'Algerienne des Eaux", by abbreviation "ADE", is a national public establishment of an industrial and commercial nature, benefiting from legal personality and financial autonomy. The Bouira unit was founded in 2003 and has an analysis laboratory responsible for controlling the quality of the water distributed to subscribers, as well as that of water coming from boreholes and reservoirs, particularly at the tap level. . Sample collections take place every morning in all ADE centers in Bouira, with a collection frequency of once or twice per week per center. Once a week, a disinfection check is carried out at the pumping stations and reservoirs.

The samples taken are then sent to the laboratory to undergo physicochemical and bacteriological analyses. This laboratory includes:

- Two analysis rooms dedicated respectively to physico-chemistry and bacteriology.
- A laboratory head's office and a quality control department head's room.
- Two offices of heads of bacteriological and physico-chemical departments.
- A storage room (reagent, culture media), a room for preparing chemical solutions.
- A meeting room and a laundry room.

Figure 4:ADE central laboratory in Bouira.

2.2 Laboratory role

One of the main missions of the Bouira ADE is to guarantee compliance and monitoring of the quality of the water distributed, so that it is suitable for human consumption, whether in its natural or treated state. This includes its appearance, smell, taste, as well as its microbiological, chemical and physical characteristics, in accordance with legal standards. The ADE must ensure that water meets several criteria to be considered fit for human consumption. His responsibilities include:

- To ensure the availability of water to citizens and to operate and install management and maintenance systems allowing the production, treatment, transfer, storage and distribution of drinking and industrial water.
- To ensure project management and project management on its own behalf and or that of local authorities.
- To carry out the task of the water police.

2.3 ADE organization chart

Figure 6 shows the organization chart of Algerian Waters from the Algiers Regional Directorate, showing that the Bouira unit falls under the Tizi Ouzou zone. This unit is organized into six centers: Bouira, Lakhdaria, Bordj Okhris, Sour El Ghozlane, Ain Bessem and M'chadallah. It is responsible for the management of a group of 30 municipalities out of the 45 in the wilaya.

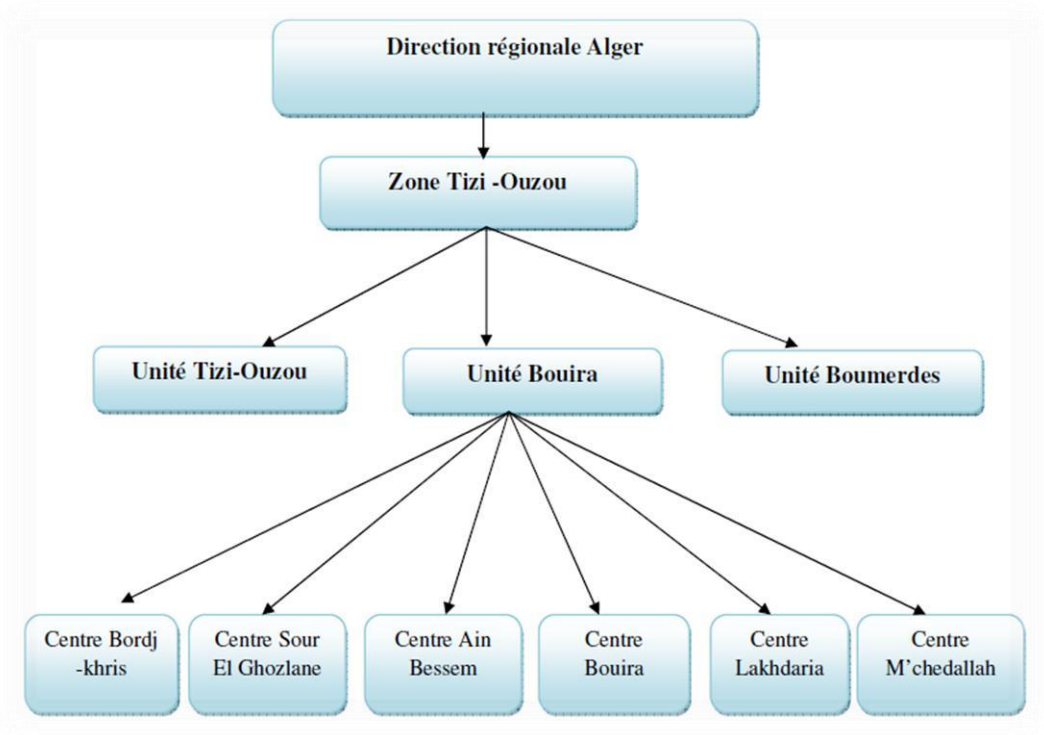


Figure 5:organizational chart of the regional ADE of Algiers.

3. Presentation of the study region

3.1 Geographic location

The wilaya of Bouira is located in the north-central part of the country, approximately 120 km southeast of Algiers. Its territory extends over 4456.26 km², which represents approximately 0.19% of the national area. The region is delimited by the mountain ranges of Djurdjura and Bibans to the southeast, and it is bordered to the north by the wilayas of Boumerdès and Tizi-Ouzou, to the southwest by the mountains of Dirah and the region of M'sila , and to the west by the regions of Médéa and Blida (Arour, 2014).

3.2 Landforms and climate

Topographically and climatically, Bouira is characterized by limestone soils in the mountainous areas and clayey soils in the plains. Its climate varies between hot and dry in summer, and cold and rainy in winter, with an average rainfall of 660 mm/year in the north and 400 mm/year in the south. Temperatures range between 20 and 40°C from May to September and between 2 and 12°C from January to March (Andi, 2015).

3.3 Hydrology of the study region

Regarding hydrology, the region has significant water resources, with proven reserves of 235.4 million cubic meters, including 35.5 million in groundwater and 199.9 million in surface water. (ADE,2019).

4 Material and methods

4.1 Material

4.1.1. Equipment and devices used for physicochemical analysis

Table 2: Materials and devices used for physico-chemical analysis.

Glass factory	Electronics
Bottle, wash bottle Pipette, graduated test tube Beaker, Burette with tap Colorless glass bowl, 50mm diameter	The conductivity meter The turbidimeter The pH meter The spectrophotometer

4.1.2. Specific materials and products used for bacteriological analysis

Table 3: Materials and devices used for bacteriological analysis.

Electronics	Glass factory	Media and reagents
-Sterilization oven -Biological ovens (37C°and 44C°) -Benzene nozzle -Colony counter -Marie bath -Autoclave	- Pliers -250ml bottles -Petri dishes -Sterile pasteur pipettes -Test tube -Cotton and aluminum foil	-BCPL midfielder -Middle Schubert - Kovacs reagent -Middle Roth -Middle Eva Litsky -Middle meat liver -Middle TGEA - Sodium thiosulfates

4.2 Methods

4.2.1. Physico-chemical analysis method

The water samples taken in the field were collected in collaboration with engineers and technicians from the ADE of Bouira. Regular sampling is carried out for basic chemical analyses, also called ACR (pH, temperature, conductivity, turbidity and TDS). Other analyzes are carried out weekly or monthly depending on the objective of the ADE. These are comprehensive chemical analyses, or ACC (iron, manganese, nitrate, nitrite, sulfate, etc.).

4.2.1.1. Sampling method

Water sampling is a critical step requiring great attention, as it directly influences the analytical results and their subsequent interpretation. The sample must be representative and homogeneous, without altering the characteristics of the water. Here are the steps to follow:

- Open the faucet at maximum flow for 5 to 10 seconds.
- Perform the chlorine test using the DPD1 or DPD4.
- Rinse the vials three times with water to be analyzed, then fill them to the top.
- Place the cap so as to avoid the formation of air bubbles and to ensure that it does not come loose during transport.
- Store and transport the vials in a refrigerated cooler at 4°C (figure 6), in isothermal packaging to guarantee their optimal conservation, then transport them and analyze them the same day at the analysis laboratory.

To prevent any alteration of the water in the bottles (Figure 7), analyzes must be carried out within 24 hours of sampling.

Figure 6: Cooler for storing and transporting water samples

Figure 7:water bottles used for physicochemical analysis.

- As part of our study, we carried out 12 groundwater samples, including 5 wells (Tachemlit, Kalous, YoftisKadiria, Mahouen, Merdja), 4 boreholes (Ain bessam, Selloum, Said abid, Sidi ziane) and 3 sources (Thikentart, Dechmia, Ait laziz).

4.2.1.2. Methods used for Physico-chemical analysis

4.2.1.2.1. Reduced chemical analyzes (ACR)

A. pH determination

- **Principle**

pH measures the chemical activity of hydrogen ions (H+) in solution. The pH measurement is carried out using a pH meter.

- **Operating mode**

✓ To measure the pH of a water sample, first turn on and calibrate the pH meter using buffer solutions, checking the calibration with a pH standard = 7 ± 0.5%. Install the electrodes to the corresponding inputs on the device. Calibrate the pH meter with the buffer solution, then rinse the electrode with distilled water and the sample to be analyzed. Fill a beaker with 100 ml of the water to be analyzed and immerse the pH meter electrode in the sample. Press the "pH" button, wait for the beep, then note the pH values displayed.

✓ **Expression of results**

pH values are directly obtained from the pH meter reading (Figure 8).

Figure 8:pH meter.

B. Temperature (T°)

- **Principle**

The temperature is determined directly using a digital thermometer incorporated into the conductivity meter. It is a device that has two electrodes, one placed inside the device and the other is immersed in the solution, the temperature will be displayed directly on the screen in °C.

❖ **Operating mode**

✓ The probe equipped with a thermometer is immersed in a beaker which contains the samples to be analyzed. The conductivity meter is allowed to stabilize then the reading is taken and reported on the analysis protocol.

C. Electrical conductivity

❖ **Principle**

Conductivity is linked to the presence of ions in solution. It increases with temperature and the concentration of dissolved salts.

❖ **Operating mode**

✓ To measure the electrical conductivity of a water sample, first turn on and calibrate the conductivity meter using a standard potassium chloride (KCl) solution at 180.0 ± 2% µS/cm. Gently shake the sample and pour 100 ml of the water to be analyzed into a clean beaker. Rinse the probe with ultrapure water, then with the water to be analyzed. Immerse the probe in the sample and remove air bubbles by gently shaking the probe while the measurement stabilizes. Record the electrical conductivity value and temperature displayed on the device after the reading stabilizes. Finally, rinse the probe and turn off the device.

❖ **Expression of results:**

The result is given directly on the device in µS/cm (figure 9).

Figure 9: Electrical conductivity meter.

D. Turbidity measurement:

❖ **Principle:**

It is measured by the Nephelometric method; the light beam passes horizontally through the bowl containing the sample, part of this light is scattered by the Tyndall effect thanks to the suspended particles. The electron photomultiplier located at an angle of 90° to the light beam captures the scattered photons and transforms this light energy into an electrical signal whose potential depends on the turbidity.

❖ **Operating mode:**

✓ To measure the turbidity of a water sample, first calibrate the turbidimeter using 0 standard solutions. Verify the reliability of the calibration by measuring the turbidity of one of the standard solutions. Shake the bottle containing the water to be analyzed. Rinse the cuvette with ultrapure water, then fill it with 10 ml of the water to be analyzed. Clean the bowl and make sure its surface is dry and free of stains. Place the cuvette in the measuring well, checking that there are no air bubbles, then close the cover and press "READ". Note the maximum value displayed.

❖ **Expression of results**

Reading is done directly on the device screen; the measurement is obtained directly in NTU (Figure 10).

Figure 10: The turbidimeter and its measuring tank.

4.2.1.2.2. Pollution parameters

A. Nitrite dosage (NO2-)

❖ **Principle**

Nitrite ions react in an acidic medium (pH=1.9) with the 4-amino benzene sulfonamide reagent (NH2 C6H2 SO2 NH2) in the presence of orthophosphoric acid to form a diazo salt which

forms a pink coloring complex with the dihydrochlorihydrate of N-(Naphthyl1)diamino-1,2ethane (C12 H16 Cl12 N2). This is a spectrophotometric measurement which is carried out at the wavelength λ=540 nm. The method is applicable to concentrations of nitrite ions up to [N] = 0.25 mg /l of NO2 at higher concentrations a dilution must be appreciated (Villers et al., 2005).

The pink color formation indicates the presence of nitrites (See figure 11).

❖ **Operating mode**

✓ To analyze a water sample spectrophotometrically, start by taking 40 ml of the water to be analyzed. Add 1 ml of Color Reagent I, then immediately mix by swirling. Then make up to 50 ml with water, checking that the pH reaches 19. Leave to sit for 20 minutes. Take the readings using spectrophotometry by setting the wavelength to 540 nm.

❖ **Expression of results**

The result given is the nitrous nitrogen content N-NO2 expressed in mg/l. To obtain the nitrite NO2 content, multiply this result by 3.29.

Noticed

Samples must be analyzed within 24 hours of collection, otherwise keep them between 2 and 5C°; in the case of cloudy samples, they must be filtered using a 0.45 µm membrane filter. If the coloring of the sample is likely to interfere, a second test portion is processed but replacing the colored reagent with 1ml of the H3PO4 solution.

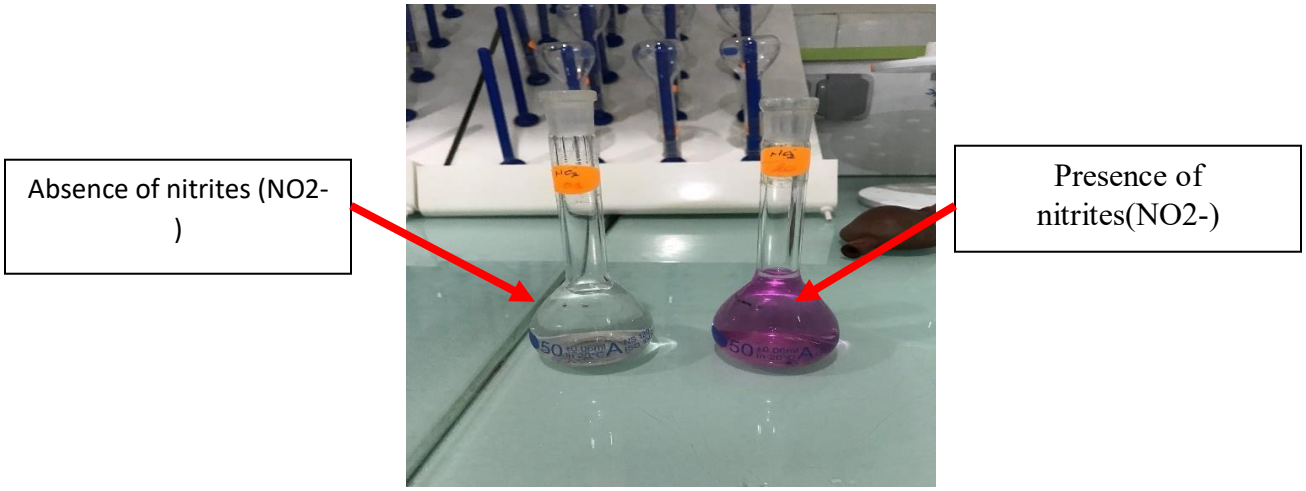


Figure 11: Dosage of nitrites (NO2-)

B. Ammonium dosage (NH4+)

❖ **Principle**

Ammonium reacts with hypochlorite ions (which are generated by alkaline hydrolysis of the sodium salt of sodium dichloroisocyanurates) to form chlorine amines which will subsequently react with sodium salicylate at pH=12.6 in the presence of Nitrosopentacyanoferrate III to form a blue compound of sodium citrate incorporated into the reagents to mask interference from cations including calcium and magnesium. The blue compound is measured spectrometrically at the wavelength λ max=655 nm. The application of this method to very colored or salty water requires prior distillation (**Cawst, 2013).**

❖ **Operating mode**

✓ To analyze a water sample spectrophotometrically, start by taking 40 ml of the water to be analyzed. Add 4 ml of color reagent and mix the solution well. Next, add 4 ml of sodium dichloroiscyanurate solution, making sure the pH reaches 12.6. Make up with distilled water until you obtain a total volume of 50 ml. Let sit for at least 60 minutes. Ensure that all assays and calibrations are carried out at the same temperature of 25°C, using a water bath if necessary. Finally, take the spectrophotometer readings at a wavelength of 655 nm.

❖ **Expression of results**

The result gives the ammoniacal nitrogen content expressed in mg/l to obtain NH4+ multiply this result by 1.28.

The results obtained during the ammonium dosage are represented in (figure 12):

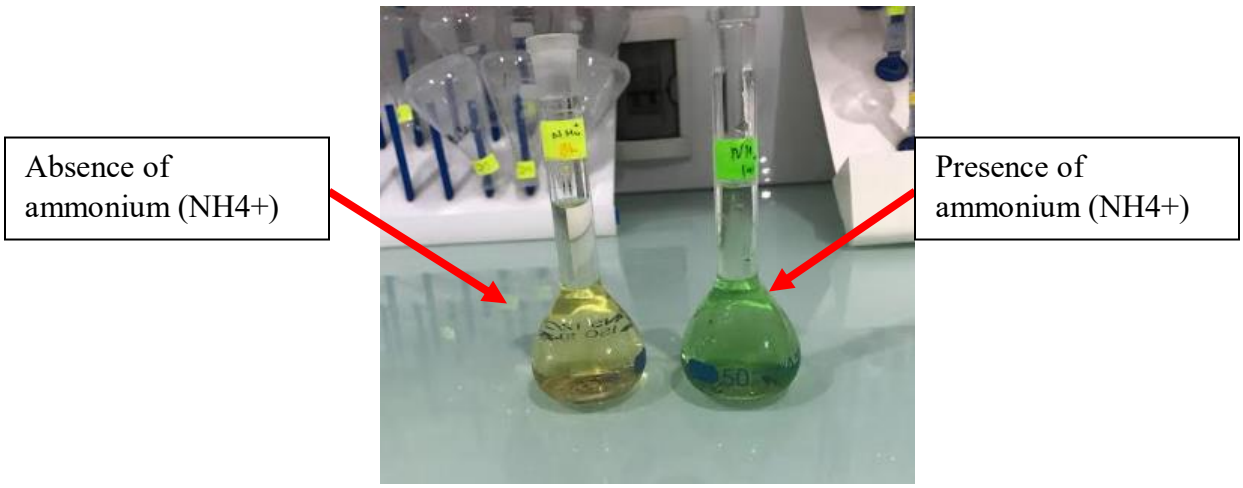


Figure 12: Ammonium dosage (NH4+).

C. Dosage of ortho phosphate ions (PO43-)

❖ **Principle**

Orthophosphate ions react with an acidic solution containing molybdate and antimony ions to form an antimonyl-phosphomolybdate complex, it is reduced by ascorbic acid to form a strongly blue-colored molybdenum complex which is assayed spectrometrically at the wavelength λ max=880nm (Hèlène, 2000).

❖ **Operating mode**

✓ To analyze a water sample spectrophotometrically, start by taking 40 ml of the water to be analyzed. Add 1 ml of ascorbic acid and shake the solution well. Then add 2 ml of molybdate solution and make up with distilled water until reaching a total volume of 50 ml. Let the solution sit for 10 to 30 minutes. Take the readings on the spectrophotometer by setting the wavelength to 880 nm.

❖ **Expression of results**

The result gives the phosphorus content expressed in mg/l and to obtain the ortho phosphate content PO43-, multiply the result by 3.06.

The results of the phosphate dosage are shown in figure 13:

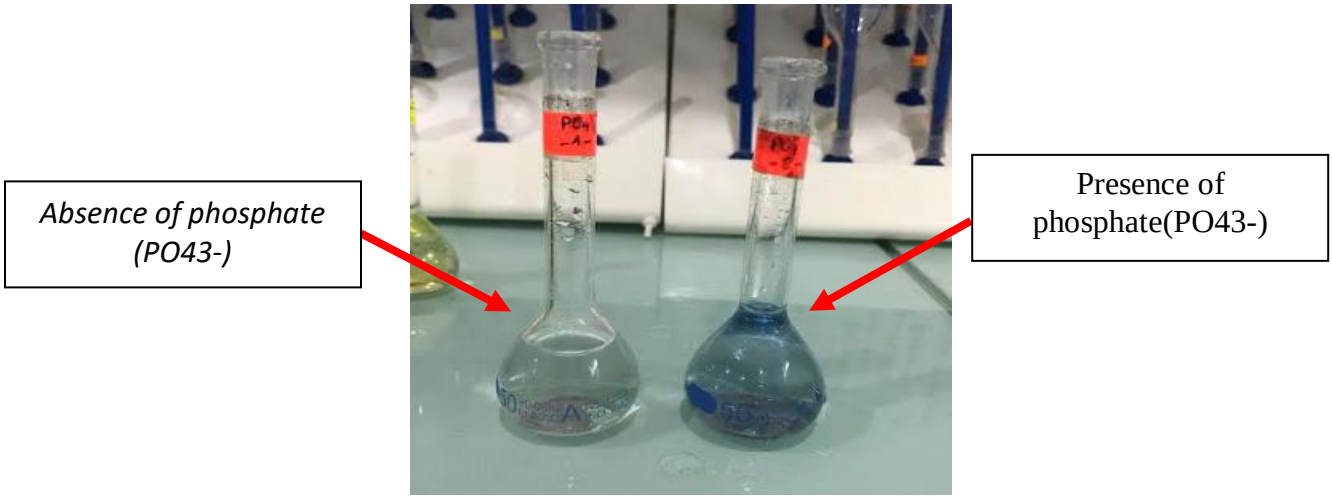


Figure 13: Dosage of phosphates (PO43-).

4.2.2. Bacteriological analysis method

To determine the quality of the water sampled daily, different types of bacteriological analyzes must be carried out: reduced biological analyzes or ABR and complete ABC biological analyzes which are done once a week or a month following the objectives of the ADE . There are two methods for achieving these parameters: The membrane filter method (on a solid medium), and the enumeration method (in a liquid medium).

Germs indicating fecal contamination are sought, these are:

- Total and fecal coliforms.
- *Enterococci*feces.
- *Clostridium*reducing sulfito.
- Total germs.

The parameters are made using the enumeration method (in liquid medium) only for untreated raw water.

4.2.2.1. Sampling method

- **Washing and sterilization**

Bacteriological samples must be collected in bottles subject to rigorous cleaning and good sterilization. These bottles are immersed for 24 hours in water containing a detergent. After that, they are cleaned with a brush and bottle brush on all surfaces and rinsed with tap water and then with distilled water 3-4 times. They are then dried in the open air, a few drops of sodium thiosulphates are added to them in order to deactivate the chlorine function in water which has undergone chlorine disinfection, finally they are sterilized in an oven at 170°C for two hours .

- **Taking water samples**

Sampling is the most important step during a bacteriological analysis of water (figure 14). However, good results can only be achieved if the samples have been correctly taken, that is to say, in such a way as to most accurately represent the environment from which the water comes. The sampling procedures vary depending on the water source: In the case of water distributed by pipe, sampling is done from a tap, handling is carried out as follows:

- Wash hands and forearms thoroughly, rinse with alcohol, allow to dry.
- Open the tap and let it run for 2 minutes then do a chlorine test.
- Turn off the tap.

- Take iron tongs coated with cotton and alcohol, vigorously flame the tap opening for 1 minute.
- Open the tap and let it run for 2 to 3 minutes to cool before taking the sample.
- It is desirable to keep the flame above the tap.
- Take the bottle with your left hand and quickly flame the edge of the neck and fill with the sample (do not fill completely), leave O2 so as not to suffocate the germs and flame the neck a second time and close well, wrap the cap with aluminum foil.
- Label the sample and record in a notebook.

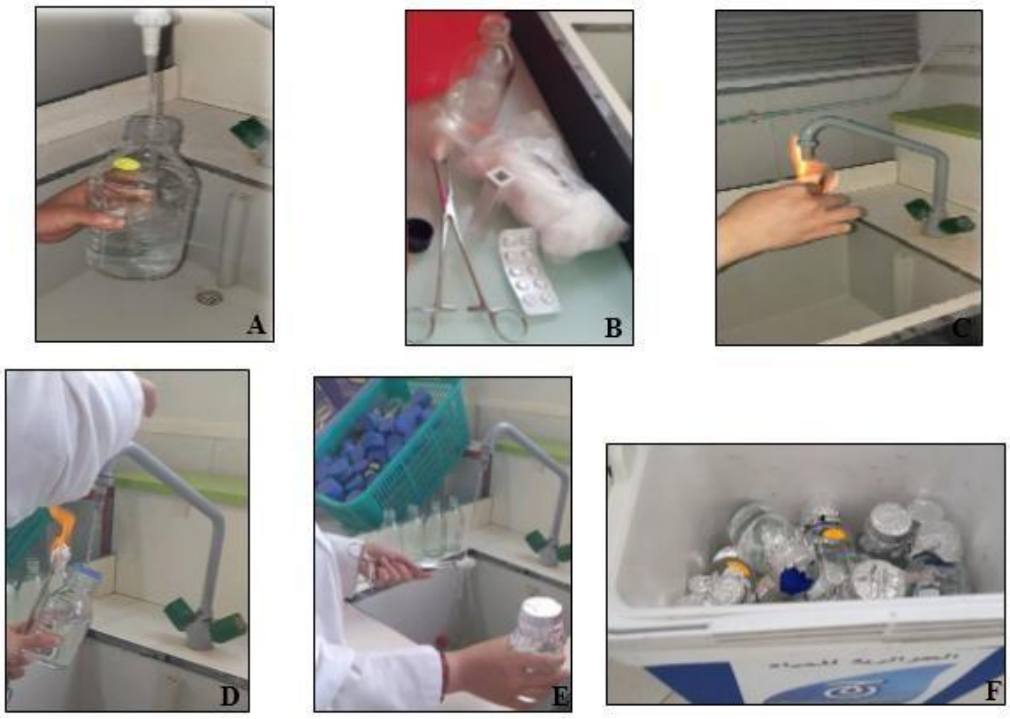


Figure 14: Sampling methodology (A: Rinsing the bottles; B: Sterilization tools; C: Sterilizing the tap; D: Filling the bottles E: Bottle ready for storage; F: Storage).

❖ For our research, we took twelve groundwater samples. This includes 5 wells (Tachemlit, Kalous, YoftisKadiria, Mahouen, Merdja), 4 boreholes (Ain bessam, Selloum, Said abid, Sidi ziane) and 3 sources (Thikentart, Dechmia, Ait laziz).

- **Transport and storage in the laboratory**

In order to avoid any modification that the water in the bottle may undergo, the analysis must be carried out very quickly. Therefore, when the transport time exceeds one hour and the outside

temperature is above 10°C, the samples must be transported in coolers with a temperature between 4 and 6°C.

4.2.2.2. Methods used for bacteriological analysis

Noticed : For more details on the composition of bacteriological culture media: see (ANNEX III)

4.2.2.2.1 Reduced Bacteriological Analyzes (ABR)

A. Detection and enumeration of total and fecal coliforms

❖ **Principle**

The enumeration of total coliforms and fecal coliforms using lactose broth with Bromocresol purple, all tubes are fitted with Durham bells to detect the possible release of gas in the medium.

❖ **Culture media**

✓ Lactose broth with Bromocresol purple (BCPL) at double concentration (D/C).

✓ Bromocresol purple lactose broth (BCPL) at single concentration (S/C).

✓ Confirmation medium: SCHUBERT broth.

✓ KOVACS reagent for indole testing.

❖ **Operating mode**

The liquid medium technique uses two consecutive tests, namely:

• **Presumption test**

It is reserved for the detection of total coliforms. From the water to be analyzed carried aseptically

➢ 3 times 10 ml in 3 tubes containing 10 ml of BCPL D/C medium fitted with a Durham bell.

➢ 3 times 1 ml in 3 tubes containing 10 ml of BCPL S/C medium fitted with a Durham bell.

➢ 3 times 0.1 ml in 3 tubes containing 10 ml of BCPL S/C medium fitted with a Durham bell.

➢ Expel any gas present in the bells and mix the medium well.

➢ Incubation takes place at 37°C for 24 to 48 hours.

Tubes presenting both:

✓ Gas release (greater than 1/10 of the height of the bell).

✓ A microbial disorder accompanied by a change in the medium to yellow (which constitutes an indicator of the fermentation of the lactose present in the medium) (see figure 15).

❖ **Expression of results**

Note the final number of positive tubes in each series and refer to the Mac Grady table (NPP) to obtain the number of coliforms present in 100 ml of water to be analyzed (ANNEX II).

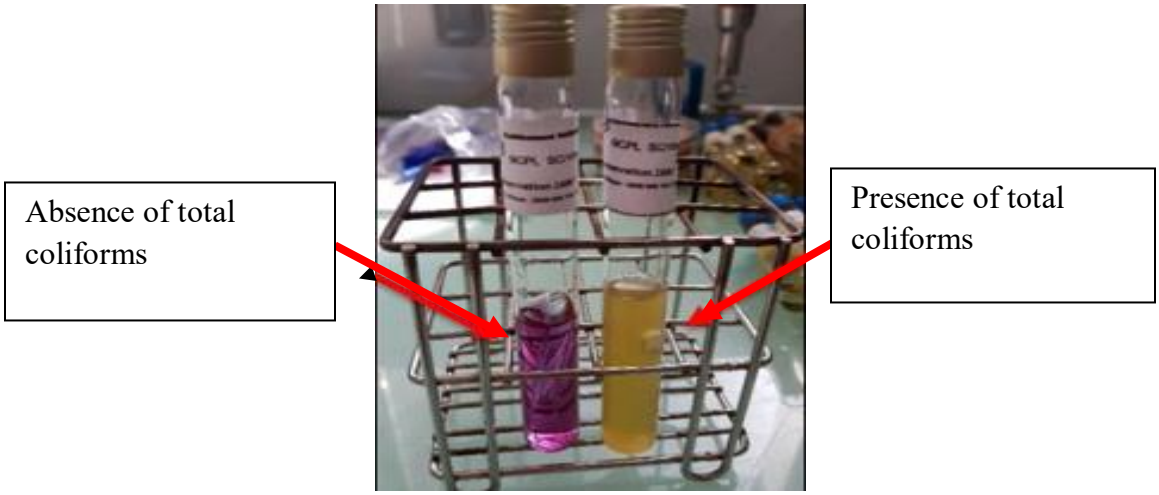


Figure 15: The result of the search for Total Coliforms.

- **Confirmatory test**

The confirmation test also called the Mac Kenzie test and based on the search for thermotolerant coliforms among which the presence of E. Coli. The BCPL tubes found positive during the enumeration of total coliforms are subcultured using a loop of 2 to 3 drops in a tube containing the indole mannitol medium (SCHUBERT) fitted with a bell. of Durham (figure 16).

- This time, the incubation takes place at 44°C for 24 hours.
- Note the number of positive tubes in each series and refer to the MPN table to obtain the number of fecal coliforms in the water. (Appendix II).

The presence of fecal coliform (figure 17) is manifested by a gas release (greater than 1/10 of the height of the bell) and a red ring on the surface, indicating the production of indole by Escherichia Coli after addition of 2 to 3 drops of Kovacs reagent (figure 18).

❖ **Expression of results**

The enumeration of fecal coliforms is carried out in the same way as that of total coliforms and the results are expressed in 100 ml of water to be analyzed.

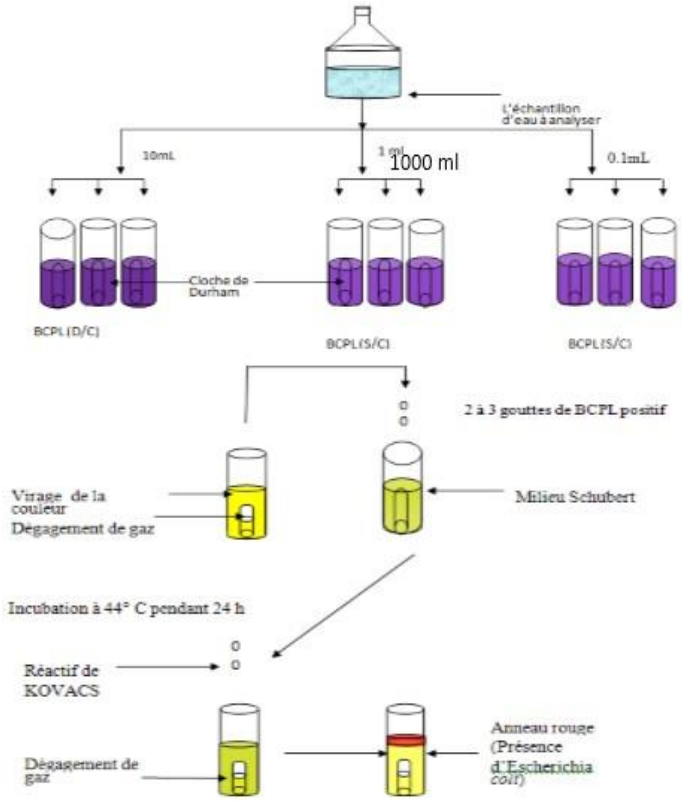
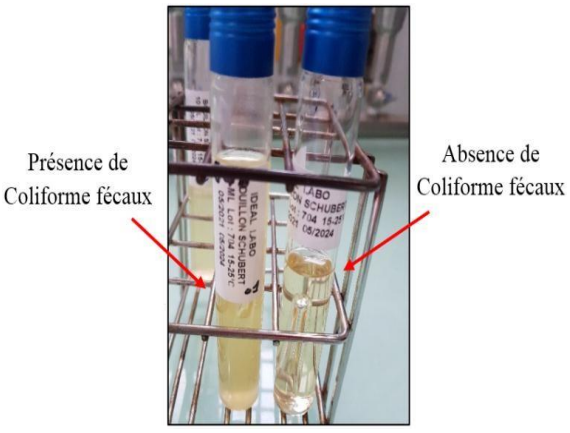


Figure 16: Detection and enumeration of total and fecal coliforms in water



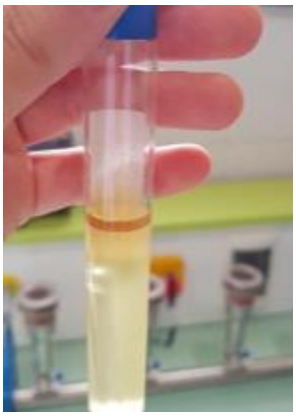


Figure 17: Fecal coliform test results. **Figure 18:**Red ring representing*E.coli.*

B. Search and enumeration of fecal Enterococci

❖ Principle

Search for and count fecal Enterococci considered as indicators of fecal pollution. They have two stages:

- Presumptive search for fecal Enterococci.
- Confirmatory research for fecal Enterococci.

❖ **Culture media**

✓ Middle of ROTHE at D/Cwithout bell.

✓ Mid ROTHE to S/C without bell.

✓ Midfielder EVA LITSKY.

❖ **Operating mode**

- **Presumptive test**

From the water to be analyzed, carry aseptically:

➢ 3 tubes of 10 ml ROTHE broth (D/C) with 10 ml of water to analyze.

➢ 3 tubes of 10 ml ROTHE broth (S/C) with 1 ml of water to analyze.

➢ 3 tubes of 10 ml of ROTHE broth (S/C) with 0.1 ml of water to analyze.

➢ Mix the medium and inoculum well.

➢ Incubation takes place at 37°C for 24 to 48 hours.

❖ **Expression of results**

Tubes presenting both: A microbial disorder accompanied by a change in the environment during this period will be considered positive, which suspects the presence of a fecal Enterococcus (figure 19). The confirmatory test is obligatory.

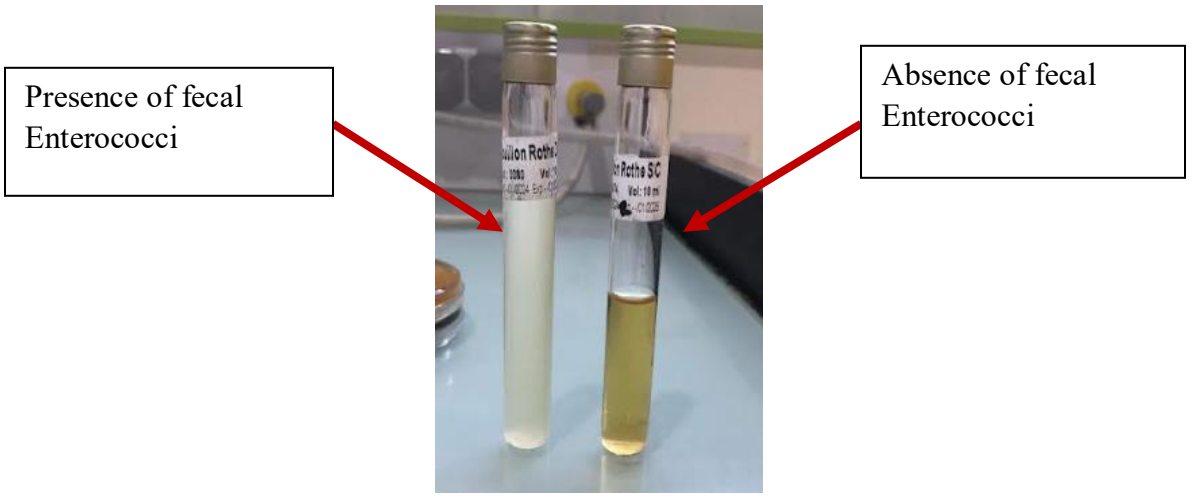


Figure 19: The result of the search for*Faecal enterococci.*

- **Confirmatory test**

➢ After shaking the positive ROTHE tubes, take a few drops from each of them using a Pasteur pipette and then transplant them into a tube containing the EVA LITSKY medium, mix the medium and the mixture well. inoculum (Figure 20).

➢ Incubation for 24 hours at 37°C.

❖ **Expression of results**

Tubes (Figure 21) presenting both:

✓ A microbial disorder.

✓ A purple pellet at the bottom of the tubes.

Note the number of positive (+) tubes in each series and refer to the NPP tables to know the number of fecal Enterococci contained in 100 ml of water (Appendix II).

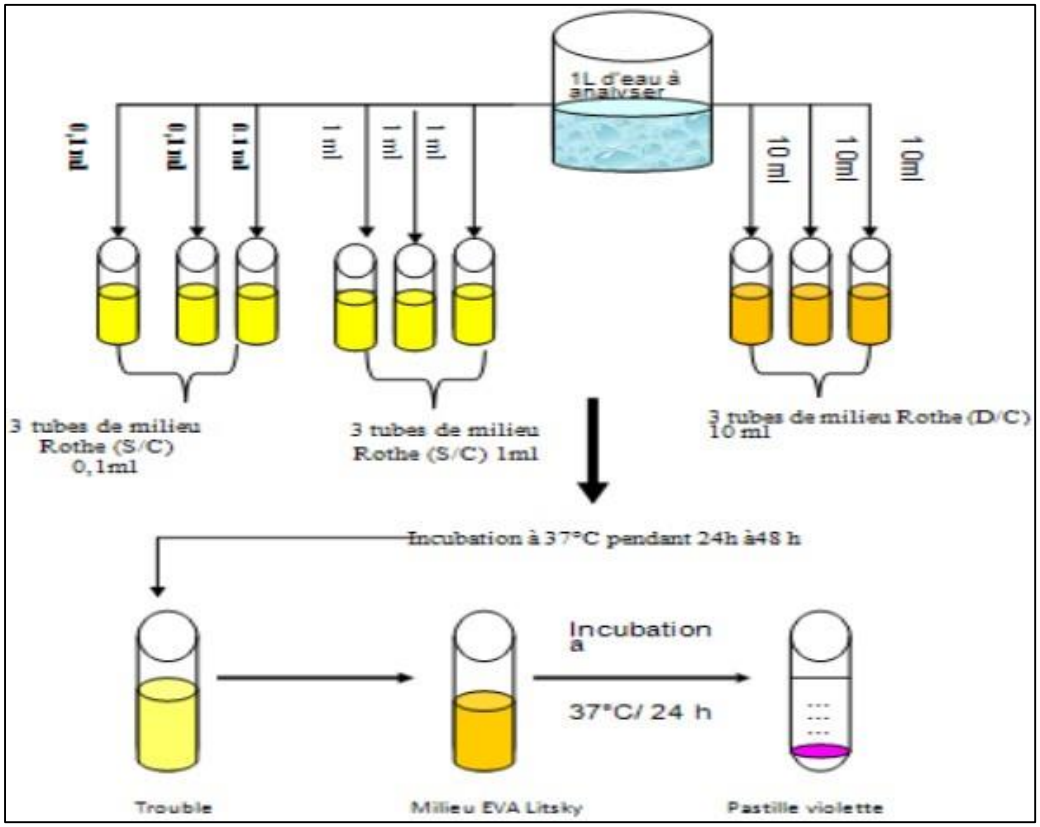


Figure 20: Search and enumeration of*Fecal enterococci in water*

Absence of fecal Enterococci

Presence of fecal Enterococci

Figure 21: The result of the search for*Faecal enterococci*.

4.2.2.2.2 Complete Bacteriological Analyzes (ABC)

C. Research and enumeration of Sulphite-Reducing Clostridium

❖ **Principle**

After destruction of the vegetative forms by heating to 80°C, only the spores will persist in the sample. The latter is incorporated into a molten base medium, generated and added with iron

salt. The presence of sulphite-reducing germs results in a black halo of iron sulphide around the colonies.

❖ **Culture centre**

- Medium Liver meat agar (VF).

❖ **Operating mode**

✓ Introduce 20 ml of water to be analyzed into 4 test tubes (5 ml in each tube).

✓ Place the tubes in a water bath at 80°C for 5 minutes.

✓ Cool suddenly under tap water (thermal shock which aims to eliminate the vegetative form and only the sporulated form of the sulphite-reducing bacteria remains).

✓ Then complete each of the tubes with approximately 15 ml of agar (liver meat) and mix carefully.

✓ Leave to solidify on the bench for approximately 30 minutes, then incubate at 37°C for 48 hours with a first reading after 16 hours of incubation, a second after 24 hours.

❖ **Expression of results**

After the incubation period, the tubes containing large black colonies will be considered positive, which corresponds to sulphite-reducing Clostridium (figure 22 and 23).

- Any black colony of 0.5 mm in diameter is counted in each tube and the total number of colonies in the 4 tubes is reported.
- The results are expressed in number of germs per 20 ml.

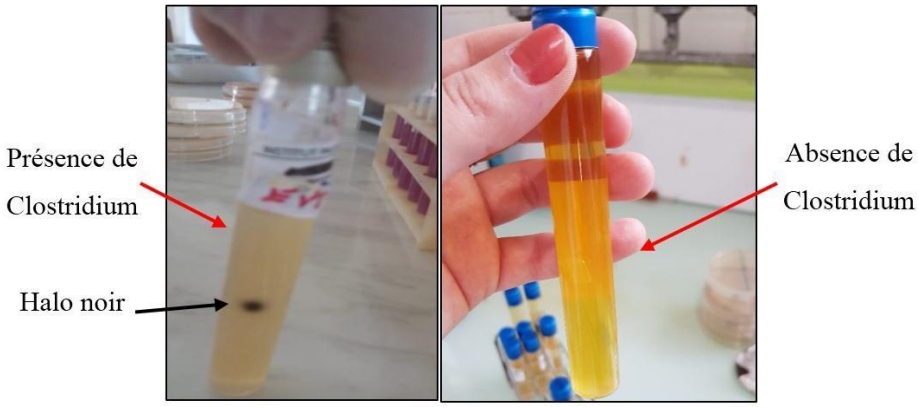


Figure 22: Search results for sulphite-reducing Clostridium

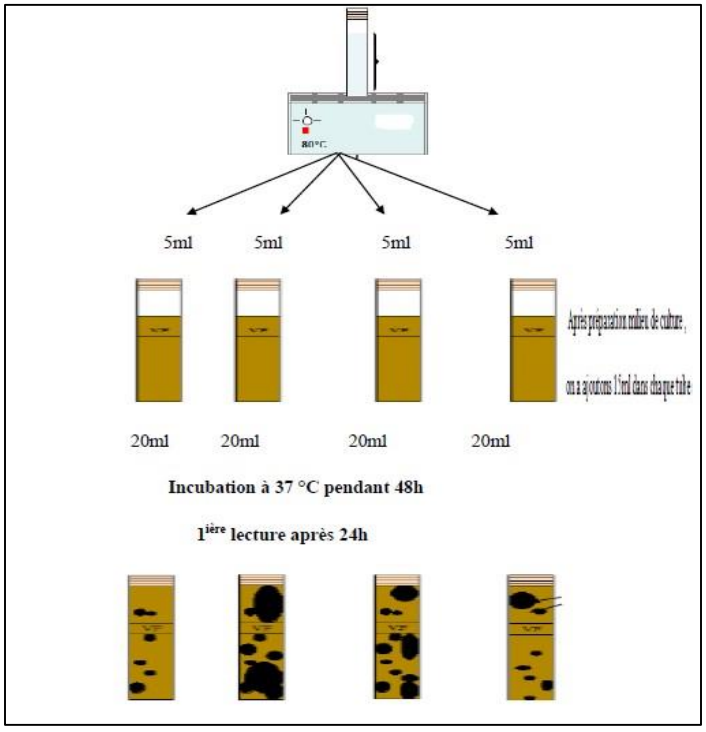


Figure 23: Research and enumeration of sulphite-reducing Clostridium

D. Search and enumeration of total germs

❖ **Principle**

The total germ count consists of an estimate of the number of total germs in the water.

❖ **Culture centre**

- Tryptone Glucose Agar with Yeast Extract (TGEA).

❖ **Operating mode**

✓ Pour 1 ml of water to be analyzed into two empty sterile petri dishes prepared for this purpose and numbered.

✓ The TGEA agar medium is melted in a water bath at 100°C and then cooled to approximately 45°C.

✓ Then complete each of the boxes with approximately 15 ml of TGEA agar and mix carefully in a rotary motion then allow to solidify.

✓ Turn the boxes over and incubate, one at 37C° for 24 hours to 48 hours (Incubation in an oven) the other at 22°C for 72 hours (Incubation in the open air) the reading is taken after every 24 hours. Figure 24 illustrates the main steps in the search for total germs.

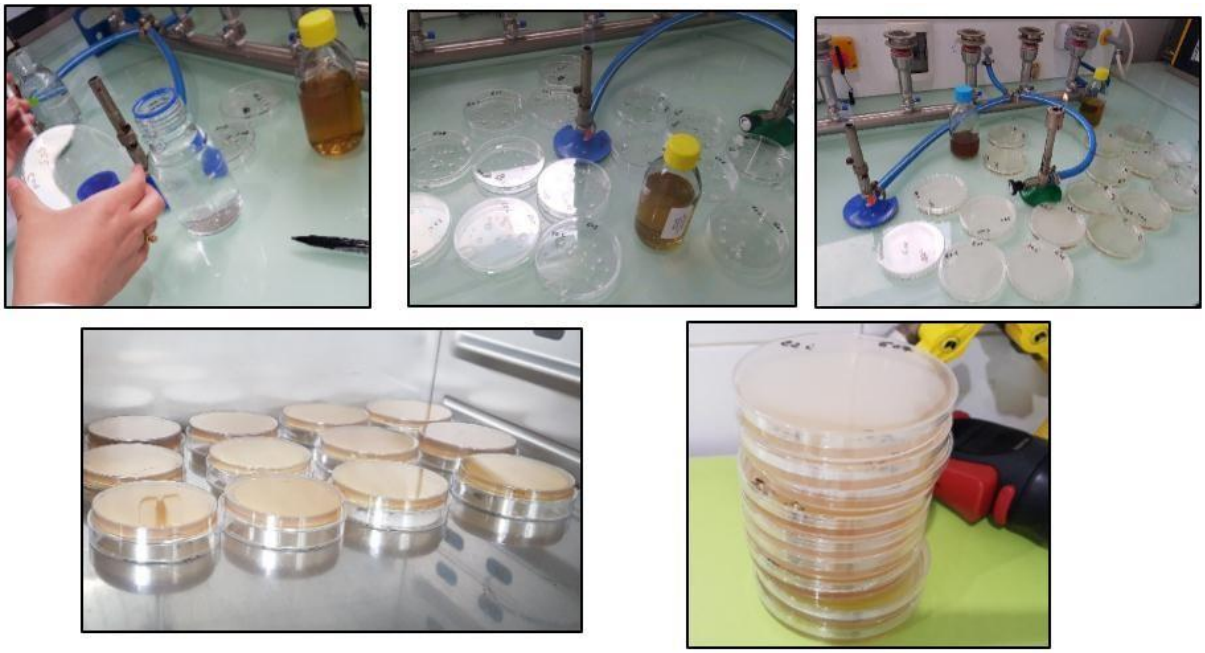


Figure 24:the stages of searching for total germs.

❖**Expression of results**

Will be considered positive; the boxes showing whitish colonies of the boxes. The results are expressed as number of germs per 1 ml (germ/1ml).

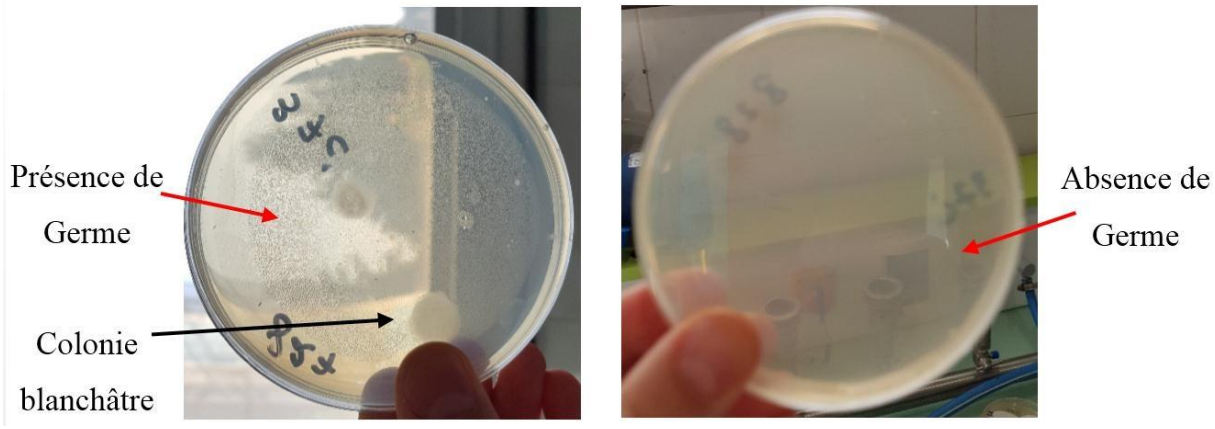


Figure 25: Total germs search results.

Chapter II

Result and discussion

Physico-chemical and bacteriological analyzes of water play an important role in determining its quality, to judge its use as drinking water. To achieve this objective, we determined in this part the evolution of the physicochemical and bacteriological parameters of the different water sources in the Bouira region.

During this chapter, we will present and discuss the main results obtained in order to detect their potability. This work was carried out on twelve different water sources (borehole, well and spring) during the months February, March and April 2024. Our samples are named as follows:

- **P1:**PuitTachemlit
- **P2:**Kalous Well
- **P3:**WellYoftisKadiria
- **P4:**PuitMahouen
- **P5:**WellMerdja
- **F1:**Ain Bessam drilling
- **F2:**Selloum drilling
- **F3:**Said Abid
- **F4:**Drilling Sidi ziane
- **S1:**Source Thikentart
- **S2:**Source Dechmia
- **S3:**Source Ait Laziz

1. Result of Reduced Physico-Chemical Analyzes (ACR)

1.1 Temperature

Generally speaking, water temperature is mainly influenced by climatic variations (Dib, 2009). The results relating to the temperature measurements of the different samples are represented in the following graph:

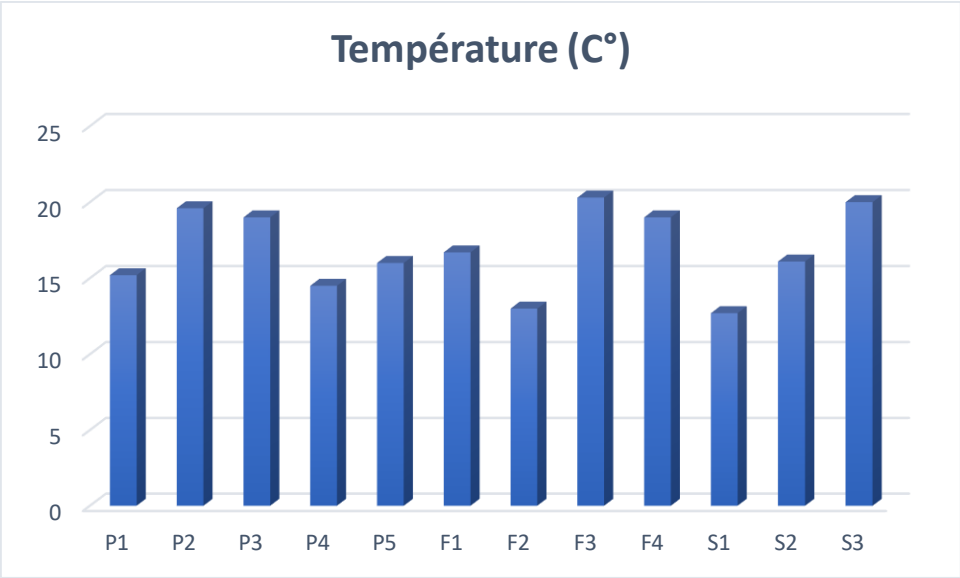


Figure 26: Graphical representation of the temperature of the water taken.

In our study, the temperatures recorded varied between 12.7°C and 20.3°C. The minimum temperature was recorded at the Thikentart spring, while the maximum value was recorded at the Said Abid borehole. The values obtained comply with national standards for drinking water, which recommend temperatures not exceeding 25°C.

Water quality is considered excellent when the temperature is between 20 and 22°C, acceptable between 22 and 25°C, and poor between 25 and 30°C (Kahoul & Touhami, 2014).

1.2 Hydrogen potential (pH)

The pH of water indicates its acidity or alkalinity. Very calcareous waters have a high pH, while those coming from soils poor in limestone or rich in silica have a pH close to 7, sometimes slightly lower, around 6. For good quality, drinkable water, the pH must be be between 6 and 8.5 (Rodier et al., 1996). The results obtained are mentioned in the figure below:

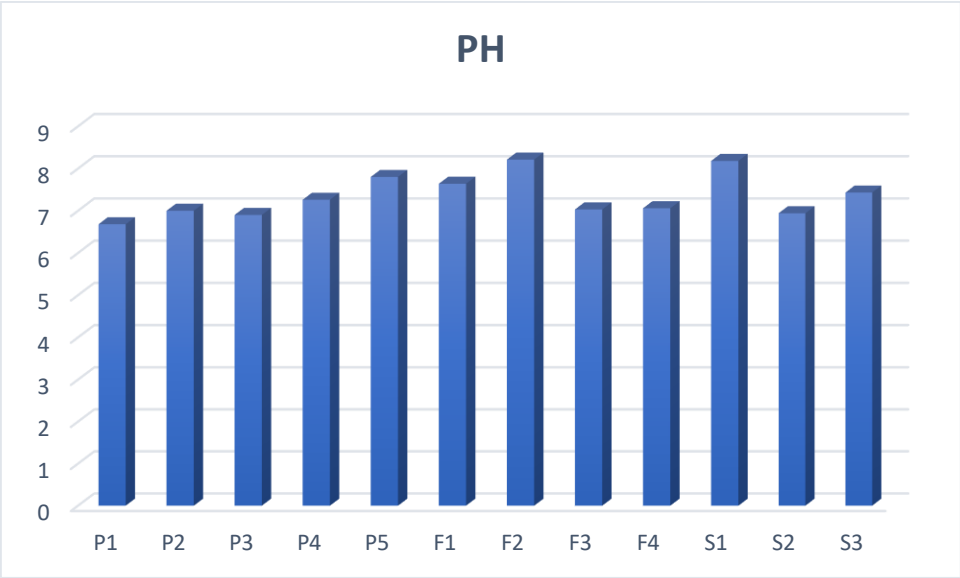


Figure 27: Graphical representation of the pH of the waters studied.

In the study region, the pH values recorded are acceptable, there is a minimum of 6.86 at the Tachemlit well and a maximum of 8.21 at the Selloum borehole. These values remain in compliance with the standards which set pH values between 6.5 and 9. In fact, our analyzed samples are of acceptable quality and are recommended for human consumption.

These values are probably due to the influence of the geochemical nature of the soil and rocks exposed by leaching action.

It is one of the most important parameters for water quality. It characterizes a large number of physico-chemical balances and depends on multiple factors, including the origin of the water. The pH of natural waters is linked to the nature of the terrain crossed (Rodier, 2009).

1.3 Electrical conductivity

Electrical conductivity makes it possible to evaluate the quantity of salts dissolved in water (Rodier et al., 2009). The results are presented in the following figure:

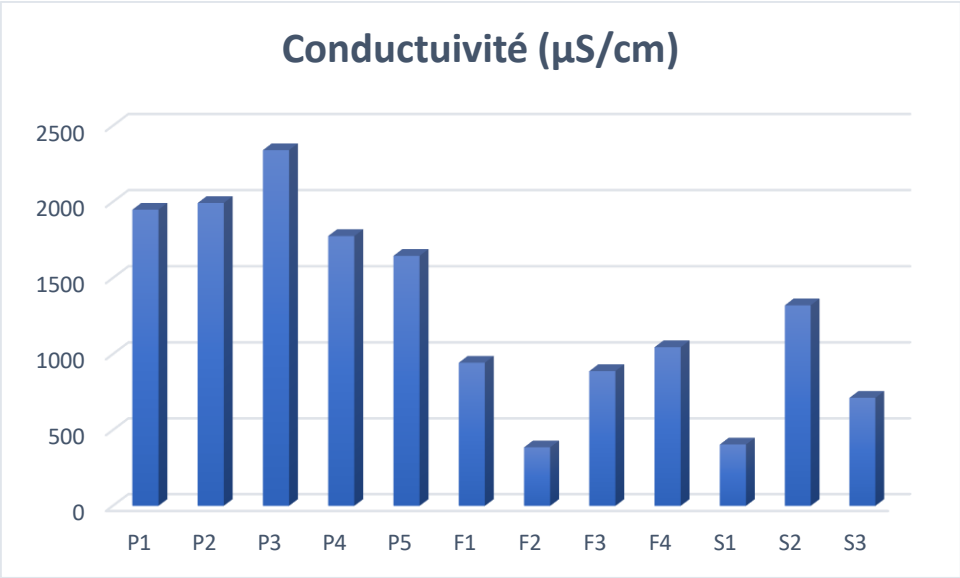


Figure 28: Graphical representation of the electrical conductivity of the water sampled.

The conductivity values recorded in our work vary between 386 µs/cm and 2340 µs/cm. The minimum value is recorded at the Selloum well level and the maximum value is recorded at the Yoftis Kadiria well level. All values do not exceed the Algerian standard which indicates a limited value of 2800 µs/cm at 20°C.

Electrical conductivity is influenced by the presence of organic matter, whether of endogenous or exogenous origin, because its decomposition and mineralization produce salts. In addition, the phenomenon of evaporation concentrates these salts in the water. Conductivity also varies depending on the geological substrate crossed (Belghiti et al., 2013).

1.4 Turbidity

Groundwater turbidity is generally inorganic and caused by natural geological factors. The results are illustrated in the following diagram:

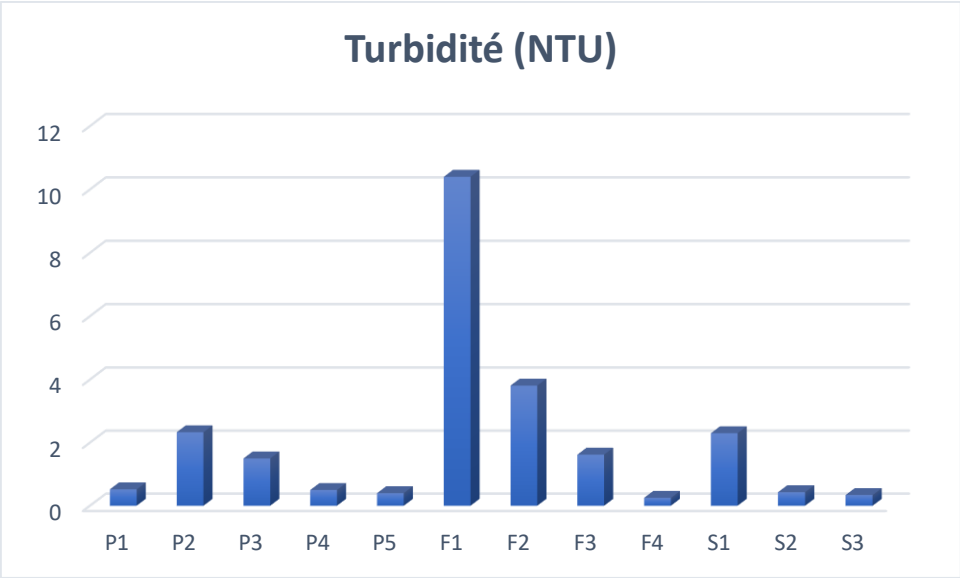


Figure 29: Graphical representation of the turbidity of the waters studied.

The waters analyzed present a turbidity which varies between 0.25 NTU and 10.4 NTU.The minimum value is recorded at the Sidi Ziane borehole and the maximum value is recorded at the Ain Bessam borehole. From these results, the different sampling points P1, P2, P3, P4, P5, F2, F3, F4, S1, S2 and S3 indicate clear water which meets the authorized standards for the turbidity of drinking water (<5 NTU),except the Ain Bessam borehole has a very high turbidity of 10.4 NTU and which exceeds the WHO standard and the Algerian potability standard.

This variation can be explained by the difference in the concentration of fine suspended particles (MES) either of natural origin, in connection with precipitation, or produced by urban and industrial discharges. For example, the Ain Bessam borehole has a higher turbidity compared to the others.

2.Results of pollution parameters

2.1 Phosphate PO43-

Phosphates alter the organoleptic qualities of water, notably odor, taste, turbidity and color (Maiga, 2005). The variations in phosphate contents in the water samples studied are represented in the figure below:

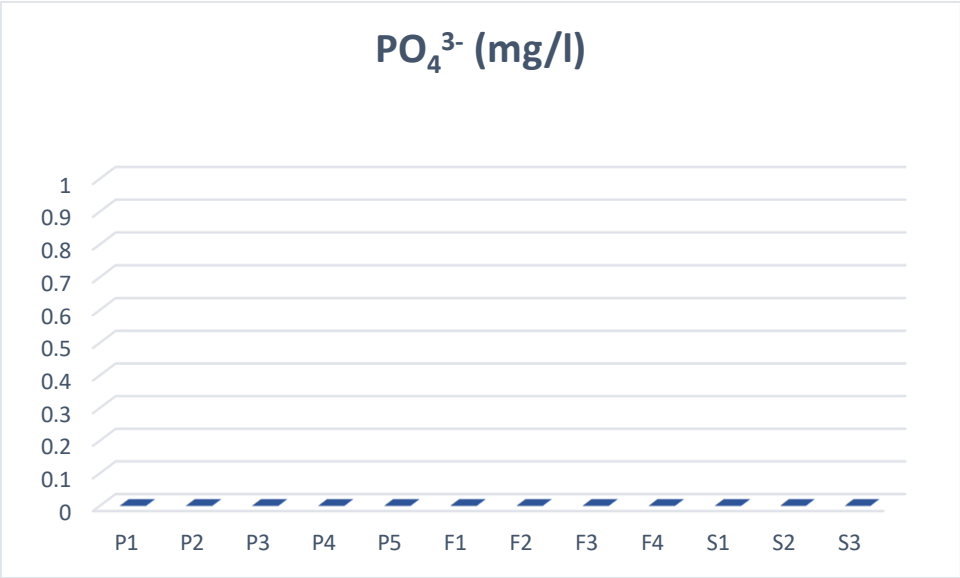


Figure 30: Graphical representation of the phosphate concentration in the samples taken.

The water analyzed does not present any risk of pollution by phosphate, because the values recorded during the analyzes are all zero (0 mg/l). The values obtained do not exceed the Algerian and WHO standards which require 0.5 mg/l. This negative result for phosphates is probably due to the total absence of contamination, whether of agricultural origin (phosphate fertilizers) or otherwise.

In natural waters, contamination with phosphorus compounds is generally caused by industrial discharges, fertilizers, detergents and fecal contamination (Baziz, 2008).

2.2 Nitrite NO2-

Nitrites are ions considered intermediate between nitrates and ammoniacal nitrogen. Their presence in significant quantities in water can alter its quality and potentially affect human health (Ghazali et al., 2013). The variations in nitrite contents in the water samples are shown in the figure below:

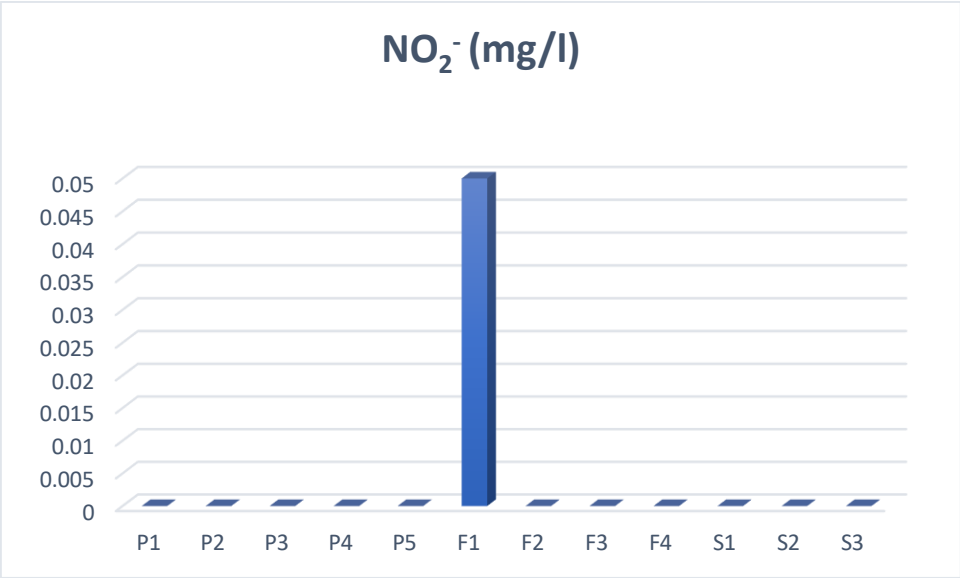


Figure 31: Graphical representation of the nitrite concentration in the samples taken.

The results obtained showed low or even zero values, except for the Ain Bessam drilling. Indeed,this value is 0.05 mg/l, it is below the recommended standard which is 0.2 mg/l and without danger for human health.

According to Dégbey's research, nitrate pollution of groundwater comes from animal waste, manure and chemical fertilizers used in agriculture, as well as contamination by seepage of various domestic, agricultural, industrial and urban pollutants. The nitrite ion (NO2-) tends to oxidize easily into nitrate ion, which explains its rare presence in high concentrations in natural waters.

2.3 Ammonium NH4+

Ammonium is considered an indicator of pollution in water, and it is crucial to eliminate it from water intended for consumption, as it can promote the proliferation of certain bacteria in distribution networks, leading to an unpleasant taste (Sari , 2014). The variations in ammonium contents are shown in the following figure:

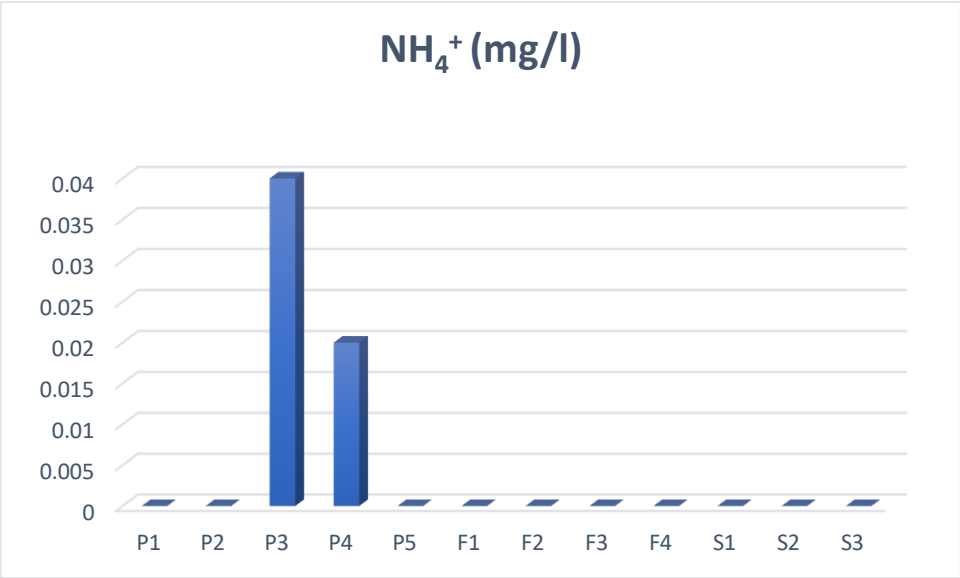


Figure 32: Graphical representation of the ammonium concentration in the samples taken.

The results indicate different values which vary from 0 to 0.04 mg/l. A concentration of 0.04 mg/l was measured at the Yoftis Kadiria well, while a value of 0.02 mg/l was recorded at the Mahouen well, otherwise for the other samples the values are zero.The concentrations in question remain below the Algerian drinking standard and the WHO which recommends a value of 0.5 mg/l.

The presence of ammonium in water indicates an incomplete degradation process of organic matter. It can also come from the excretion of living organisms and the reduction of organic nitrogen during the biodegradation of waste, without forgetting direct contributions of domestic and agricultural origin (Derwich et al., 2010).

Following the multivariate analyzes of the physicochemical results relating to the evaluation of the quality of water coming from various sources in the Bouira region, it is indicated that most of the parameters examined comply with WHO international drinking standards as well as than Algerian national standards. However, the Ain Bessam borehole presents a turbidity problem, which classifies it as poor quality water requiring clarification (Appendix IV).

3.Results of bacteriological parameters

The microbiological quality of water presents an important factor when studying its potability, for this we carried out a search for different bacterial groups likely to contaminate

drinking water. The results of microbiological analyzes of our water samples are illustrated in the following table:

Table 4: The results of bacteriological analyses.

Settings	**Unit**	**P1**	**P2**	**P3**	**P4**	**P5**	**F1**	**F2**	**F3**	**F4**	**S1**	**S2**	**S3**	**Standard**
Total Coliforms	CFU/100ml	12	13	Abs	14	101	58	13	Abs	02	Abs	Abs	Abs	00
Fecal Coliforms	CFU/100ml	Abs	13	Abs	Abs	28	09	Abs	Abs	Abs	Abs	Abs	Abs	00
Escherichia coli	CFU/100ml	Abs	Abs	Abs	Abs	Abs	Abs	Abs	Abs	Abs	Abs	Abs	Abs	00
***Streptococci* Fecal**	CFU/100ml	01	Abs	Abs	Abs	23	13	Abs	Abs	Abs	Abs	Abs	Abs	00
Germ Totals (22°C)	CFU/100ml	34	18	Abs	22	100	145	22	Abs	01	Abs	Abs	Abs	/
Germ Totals (37°C)	CFU/100ml	22	110	Abs	13	82	120	Abs	Abs	03	Abs	Abs	Abs	/
Clostridium Sulphite reducers	CFU/20ml	Abs	03	Abs	Abs	01	01	Abs	Abs	Abs	Abs	Abs	Abs	00

3.1 Total coliforms

Total coliforms have long been used as indicators of microbial water quality, because their presence can be indirectly linked to pollution of fecal origin. The direct presence of bacteria from the total coliform group is associated with a health risk (Chevalier, 2003). The total coliform results are shown in the following figure:

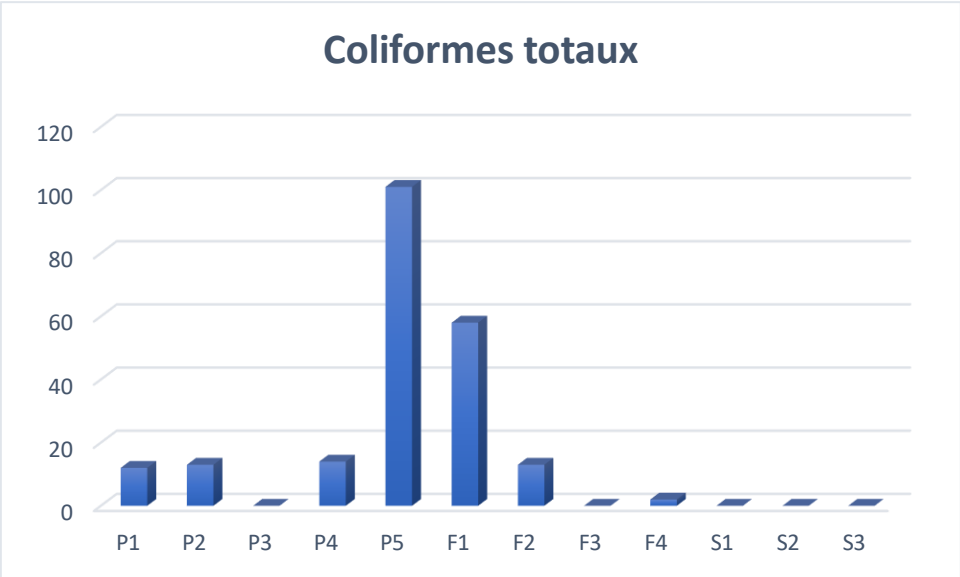


Figure 33: Graphical representation of variations in total coliforms in the waters studied.

The results of analyzes of water samples from the study area show a worrying presence in the Merdja well with a number of 101 CFU/100ml, as well as the Ain bessam borehole with a number of 58 CFU/100ml. Values ranging from 02 CFU/100ml to 14 CFU/100ml are recorded in wells P1, P2, P4 and boreholes F2 and F4 and a total absence for the other samples.

These values are high in comparison with the Algerian standard which requires the total absence of total coliforms in water intended for human consumption.

This contamination can result from domestic discharges, the proximity of wells to septic tanks, and the infiltration of surface water into wells and boreholes and sources (El Haissoufi et al., 2011).

3.2 Fecal coliforms

Detection of thermo-tolerant fecal coliforms indicates fecal contamination of water. The presence of Escherichia coli therefore indicates recent fecal pollution (WHO, 2004).The results for fecal coliforms and E. coli are shown in the following figure:

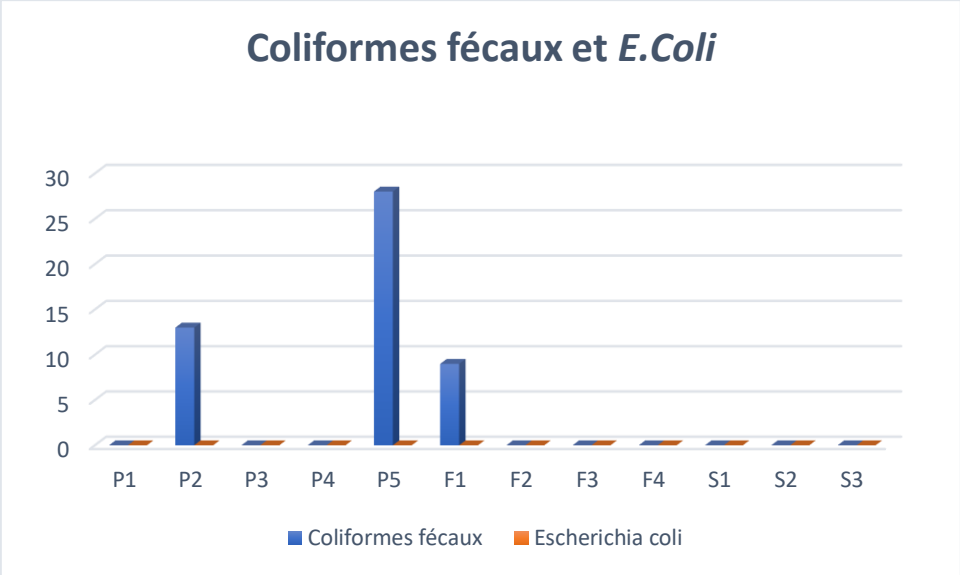


Figure 34: Graphical representation of fecal coliform variations and*E. coli in the water sampled.*

The results of the search for fecal coliforms in the water analyzed show a significant presence of fecal coliforms at the Kalous and Merdja wells with a number of 13 and 28 CFU/100ml respectively and at the Ain bessam borehole with a number of 9 CFU /100ml. These results do not comply with the Algerian standard. On the other hand, a total absence of Escherichia coli was recorded in all the waters studied.

This contamination comes from manure, septic tanks, latrines and various waste present in the land surrounding wells, boreholes and springs (Aka, 2013).

3.3 *Enterococci*fecal

The presence of Enterococci in groundwater or in springs should raise serious suspicions regarding contamination of fecal origin and the presence of enteropathogenic microorganisms (Simmons et al., 2001). The results for Fecal Enterococci are shown in the figure below:

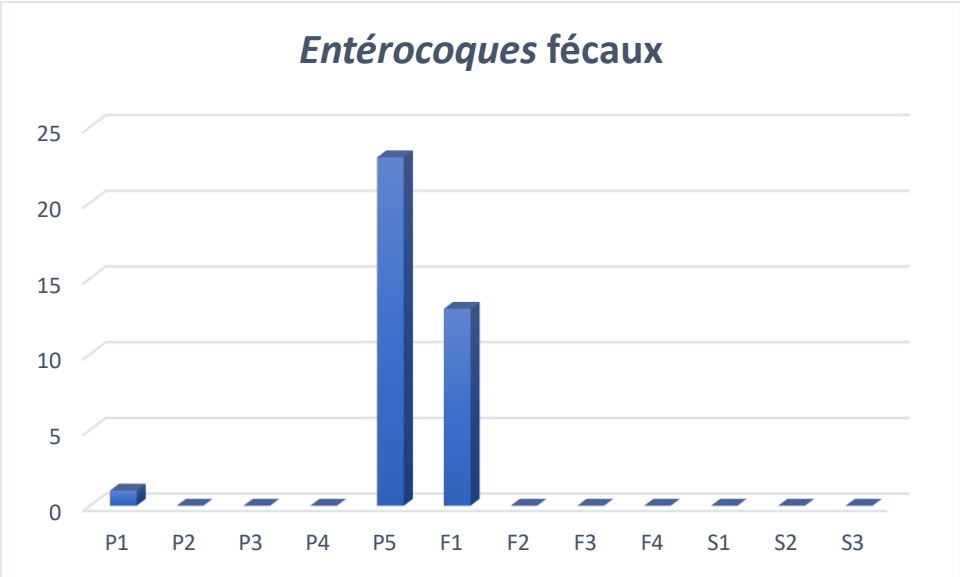


Figure 35: Graphical representation of variations in*Faecal enterococci in the waters studied.*

Bacteriological analyzes carried out on the water samples show the presence of fecal Enterococci in the Tachemlitet Merdja well with a number of 1 and 23 CFU/100ml respectively, in the Ain bessam borehole with a number of 13CFU/100ml and a total absence in the other samples. These results exceed the standard which requires the total absence of this flora in water intended for consumption.This is caused by the infiltration of wastewater or defective or poorly maintained sanitation systems, or even non-existent, and rainwater runoff and illegal deposits during this period.

Their persistence in various types of water may be greater than that of other indicator organisms, in part because of their resistance. In this context, the role of Enterococci as an indicator of old fecal contamination in aquifers (groundwater) has recently been recognized.

3.4 *Total germs*

The total germs revivable at 22°C and 37°C represent the average bacterial content in the water. They are more significant as an indicator of contamination than the numerical value itself. The results of the total germs are represented in the figures below:

- **Sprouts at 22°C**

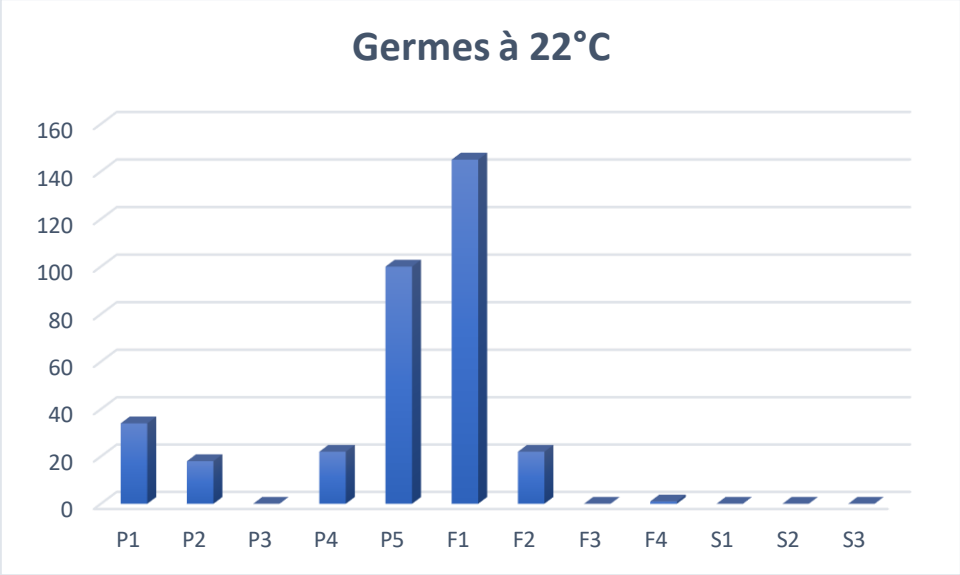


Figure 36: Graphical representation of germ variations at 22°C in the waters studied.

The water analyzed shows a significant presence of germs at 22°C at the Tachemlit, Kalous, Mahouen, Merdja wells with a number of 34, 18, 22 and 100 respectively as well as the Ain bessam and Selloum boreholes with a number of 145 and 22 at the respective order.

The total germs which can be revived at 22°C are non-pathogenic bacteria which can develop under normal culture conditions. They serve as an indicator of the possible presence of bacteriological contamination in the water.u bysewer discharges, septic tanks and animal stalls.

- **Sprouts at 37°C**

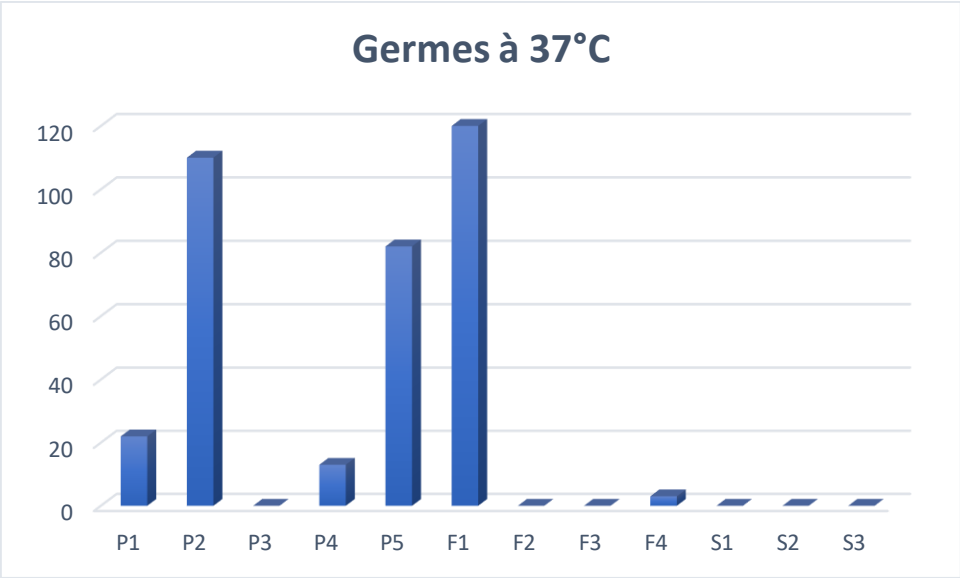


Figure 37: Graphical representation of germ variations at 37°C in the waters studied.

The results obtained show the presence of germs at 37°C at the Tachemlit, Kalous, Mahouen, Merdja and Merdja wells as well as the Ain bessam and Sidi ziane boreholes with a number of 22, 110.13, 82, 120 and 03 CFU/100ml respectively

Total germs are yeast and mold bacteria which develop after cultivation at 37°C, of multiple origin (earth, vegetation, waste water)detection indicates insufficient hygienic quality of the water and suggests sanitary contamination of the water.

3.5 *Clostridium*sulfate reducers

Sulphite-reducing Clostridium are microorganisms capable of forming spores and surviving for a long time in water, which indicates old contamination. Their resistance to disinfectants is higher than that of coliforms, making them a good indicator of disinfection effectiveness (Hamed et al., 2012). The results of Clostridium sulfito-reductor variations are shown in the following Figure:

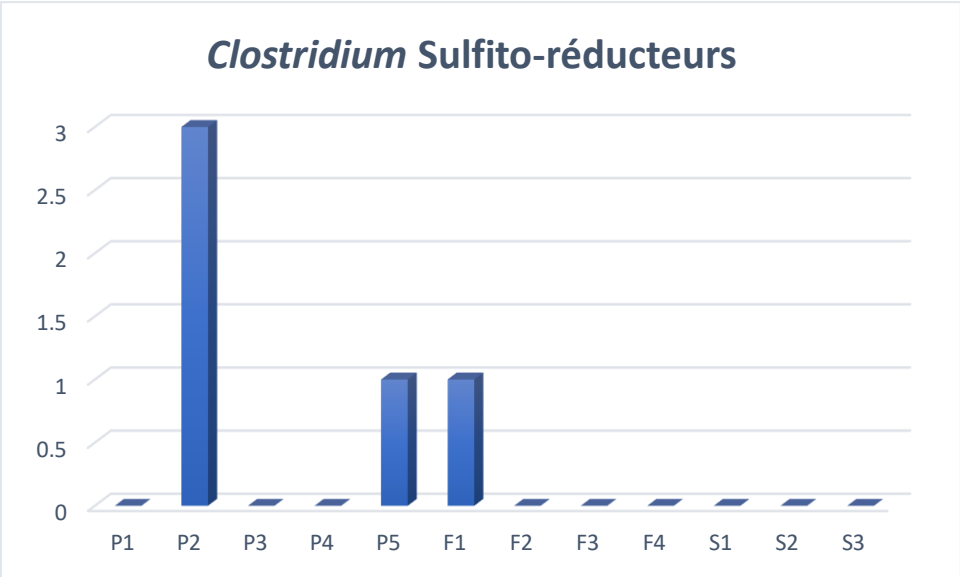


Figure 38: Graphical representation of variations in*Sulphite-reducing Clostridium in the water analyzed.*

The results obtained show the presence of sulfito-reducing Clostridium at the Kalous well with a number of 3 CFU/20ml and at the Merdja well and the Ain bessam borehole with a number of 1 CFU/20ml which indicates the presence of fecal contamination. These results are therefore non-compliant with Algerian standards.

The detection of sulfito-reducing Clostridium is strongly indicative of long-standing or intermittent fecal pollution. Their presence can be attributed to poor protection of boreholes and wells (particularly open wells), surrounding pollution (such as livestock breeding, the presence of septic tanks and latrines) and the absence of a sanitation network (Kanohin et al., 2017).

The results of the bacteriological analysis carried out on the various water sources in the Bouira region reveal the total absence of any pathogenic germs that could contaminate water intended for consumption, particularly in the sources of Thikentart, Dechmia and Ait Laziz. , as well as in the YoftisKadiria well and the Said Abid borehole. These results indicate a satisfactory microbiological quality of our samples, in compliance with the drinking standards in force in Algeria.

Water from Tachemlit, Kalous, Mahouen, Merdja wells and Ain Bessam, Selloum and Sidi Ziane boreholes reveal the presence of indicator germs such as coliforms, Enterococci and germs

which indicate a deterioration in the bacteriological quality of these waters . Disinfection treatment using bleach is recommended to ensure the safety of this water before consumption.

General conclusion

Conclusion

Drinking water is an essential resource for the human body, which can be consumed without risk to health. However, it is subject to exhaustion and deterioration of its quality due to soil characteristics and various human activities. Therefore, meeting the demand for water involves not only guaranteeing sufficient quantities, but also ensuring its quality through rigorous monitoring of its physical, chemical and biological aspects.

The objective of this modest study is to evaluate the potability of water from twelve different sources in the wilaya of Bouira, used for drinking purposes. This assessment is based on physicochemical and bacteriological analyzes carried out at the ADE laboratory in the wilaya of Bouira. The result of the physicochemical analyzes reveals that the characteristics of most of this water are within the limits of national and international standards governing drinking water, with the exception of the Ain Bessam borehole. This observation highlights that the majority of these sources have good water quality.

From a bacteriological point of view, the results of bacteriological analyzes demonstrated that the water coming from the Yoftis Kadiria well, the Said abid borehole, as well as the sources of Thikentart, Dechmia and Ait Laziz, remains consumable and has good bacteriological quality. . We observe a virtual absence of the desired germs, which confirms that this water meets drinking standards. This bacteriological quality is attributable to various factors such as the distance from homes (and therefore the absence of a sanitation network), the absence of animal waste, the reduction in human activity and favorable climatic conditions.

However, some samples analyzed revealed the presence of total and fecal coliforms, fecal Enterococci, Clostridium and total germs, indicating contamination of fecal origin. Indeed, the Tachemlit, Kalous, Mahouen, Merdja wells and the Ain Bessam, Selloum, Sidi Ziane boreholes exceed the standards established by the Algerian authorities, which represents a risk of pollution and contamination according to WHO criteria. However, the water from these sources remains of treatable bacteriological quality requiring only simple disinfection to be consumable.

Following the results of the analyzes obtained, we can conclude that the water intended for consumption in the town of Bouira has satisfactory bacteriological and physicochemical quality. To guarantee health safety when consuming this water and to better control pollution, it is recommended to take the following measures:

- Carry out regular and comprehensive monitoring of the pumping station, assessing both the quantity and quality of the water.

- Prohibit the creation of new water points in heavily exploited areas.

- Close all abandoned water points and those with equipment problems.

- Raise awareness among populations and encourage them to report any unusual change in color or odor of water distributed to consumers before consumption. It is important to reassure them that waterborne diseases can be prevented.

- Manage household waste effectively and set up a sanitation system to adequately dispose of wastewater.

Bibliographic references

Bibliographic reference

HAS

Ahonon, AS, (2011). Evaluation of the physicochemical and bacteriological quality of surface water in the mountainous areas of south-west TOGO: case of the Canton of Life, International Master, water environment and health, University of Lome, TOGO, 35p.

Aka, N. (2013). Hydrochemical and microbiological study of Alterite layers in a humid tropical climate: Case of the Abengourou Department (South-East of Ivory Coast). LARHYSS Journal P-ISSN 1112-3680/E-ISSN 2521-9782, (16).

Algerian waters of the wilaya of Bouira (ADE), (2019).

Andi.A, (2015).*Invest in Algeria, wilaya of Bouira.*Bouira.

Arour, E. Geographic location map of the wilaya of BOUIRA. Retrieved from Administrative division of Algeria & Monograph:http://decoupageadministrative algerie.blogspot.com/2014/10/bouira geographic map.html.

Arouya, K. (2011). Water pollution: impact of wastewater on quality*surface water*. European University Editions.

Arrus, R. (1985). Water in Algeria from imperialisme to development (1830-1962)", Ed Office of University Publications. Grenoble University Press.

Ayed, W. (2016). Evaluation of the physicochemical and bacteriological quality of groundwater: case of wells in the El-Harrouche region Doctoral thesis in Sciences. University August 20, Skikda, p156.

B

Balderacchi, (2009)."Water in the body», National Center for Scientific Research (CNRS).

Bara.Y. (2016)."Comparative study of the physicochemical and bacteriological quality of water from the Hammam Debagh dam before and after treatment Case of the Hammam Debagh –Guelma treatment station". Master memory. University May 8, 1945 Guelma.

Baziz, N. (2008). *"Study on the quality of drinking water and potential health risks in the city of BATNA"*, Magister's dissertation, Colonel Elhadj Lakhdar University, Batna.

Belghiti, ML, CHAHLAOUI, A., Bengoumi, D., & El Moustaine, R. (2013). Physical quality study-chemical and bacteriological of groundwater from the Plio-Quaternary aquifer in the Meknes region (Morocco). LARHYSS Journal P-ISSN 1112-3680/E-ISSN 2521-9782, (14).

Bernard, C. (2007). "Introduction to the Study of Experimental Medicine», BiblioBazaar edition.

Boeglin, J. C. (2009). Properties of natural waters, Engineering technique, environmental treatise, G1, 110p.

Boeglin, J. C. (2001). Properties of natural waters. Engineering technique, environmental treaty, G 1110.

Bordet, J. (2007). Water in its rural environment. 1st Ed Johanet. Paris. ISBN: 978-2-9000-86-71-1. Pp 53-174.

Bouziani, M. (2000). Water from shortage to diseases, Edition ibn khaldoun, 247p.

VS

Castany, G. (1982). Principles and methods of hydrogeology. Edition: Dunod. p.58.

Cawst. (2013). *Introduction to Water Quality Analysis*, Canada: Center for Affordable Water and Sanitation Technology.

Chaden, M. H. (2014). Assessment of water quality in the upper basin of the Litani River, Lebanon: hydrogeochemical approach. Doctoral thesis in geosciences. University of Lorraine. Pp99.

Chevalier, P. (2003). Total coliforms. Summary sheets on drinking water and human health. Scientific group on water, National Institute of Public Health of Quebec, p4.

Cir (international reference center for collective water supply and sanitation). (1983). Water supply to small communities. Technologies suitable for small installations in developing countries. The Hayes.

Coulibaly, K. (2005). Study of the physicochemical and bacteriological quality of water from wells in certain areas of the Bamako district. Doctoral thesis in Medicine, Pharmacy and Odonto-Stomatology. University of Bamako. Pp 33.

D

Degbey. C, Makoutode. M, Fayomi .B, Brouwer.C, (2010).*The quality of drinking water in the professional environment in Godomey, Benin,* J Int Health Trav, Vol 1, 15-22 p.

Degree. (2005):"Water technical guide", Second edition Tom1. P 39-50

Degree. (1952). Technical guide to water, 1st edition, Paris: Lavoisier-technical glossary.

Derwich E, Benaabidate L, Zian A, Sadki O, Belghity D. (2010). Physico-chemical characterization of the waters of the alluvial aquifer of Haut Sebou downstream of its confluence with Oued Fes. Larhyss Journal, 08: 101-112

Desjardins, R. (1997). Water treatment, Edition of the Polytechnic School of Montreal, 2nd edition, Quebec, Canada, PP: 46-112.

Dib, I. (2009). The impact of agricultural and urban activity on the quality of groundwater in the Gadaine-Ain Yaghout plain (Eastern Algeria), Master's thesis in hydraulics, hydro-technical construction and environment, faculty of engineering sciences, department of hydraulics, Hadj Lakhdar University, Batna, 127 p.

Dinepa, OI Water, Unicef. (2013). Sampling and analysis of drinking water for simplified laboratories. 1.3.1. FIT 1. ISBN 13-978-99970-51-24-0. Pp 27-28.

El Haissoufi, H., Berrada, S., Merzouki, M., Aabouch, M., Bennani, L., Benlemlih, M., ... &Lalami, AEO (2011). Pollution of well water in certain districts of the city of Fez, Morocco. Journal of Industrial Health and Environmental Microbiology, 5(1), 37-68.

F

Feachem, RG, Bradley, D.J and Garelick, HMDD (1983). Sanitation and disease health aspects of excreta and wastewater management. The World Bank. 1st Ed USA, pp 6-12.

Festy B, Hartemann P, Ledrans M, Levallois P, Payment P, Tricard D, (2003). Water quality. Environment and public health - Foundations and practices, Paris: Edisem, p. 333–8.

G

Gaujous, D. (1985): Pollution of aquatic environments: Reminder. Edition: revised and expanded, p. 49

Ghazali D., Zaid A. (2013): Study of the physicochemical and bacteriological quality of water from the Ain salama-jerri spring (Meknes region – Morocco). Larhyss journal, ISSN 1112-3680, n° 12, January 2013, pp. 25-36

Gleeson, C and Gray, N. (1997). The coliform index and waterborne disease: problems of microbial drinking water assessment, E & FN Spoon, London, p194.

Goita. (2014), Waterborne pathogenic bacteria from epidemiology to prevention, Doctoral thesis, Mohamed El Khamese-Souissi University, Morocco, 134 p.

Guergazi S., Achour S., 2005. Physico-chemical characteristics of the water supply to the town of Biskra: practice of chlorination. Larhyss Journal, n°4, June 2005.

Guessoum, H., Benbrahim, F., Halilat, M., Tahar, LF, Bensalama, M., & Darem, S. (2014). Microbiological Characterization of the Water Table of the Ghardaia Region (case of Sebseb).

Hailu, B. (2017). Physicochemical and microbial quality of drinking water from source to household taps: The case of Legedadi reservoir. A Thesis submitted to the Center for Environmental Science. Addis Ababa University. Ethiopia. Pp 14

Hamed, M and Guettache, A and Bouamer, L. (2012): Study of the physicochemical and bacteriological properties of water from the Djorf-Torba Bechar Dam. State Engineer's Dissertation in Biology, Béchar University of Sciences and Technologies, Béchar, Algeria, p18.

Hamed, M and Guettache, A and Bouamer, L. (2012). Study of the physicochemical and bacteriological properties of water from the Djorf-Torba Bechar Dam. State Engineer's Dissertation in Biology, Béchar University of Sciences and Technologies, Béchar, Algeria, p18.

Hartemann, P. (2013). Drinking water, risk, health. Water & Territorial Sciences, (1), 14-21.

Hélène, R. (2000). Microbiological quality of raw water distributed by BRL: Requirements and design of appropriate monitoring. Memory of the National School of Public Health, France. p81.

Hopkins, W.G. (2003). Plant physiology. From Boeck Superior.

Hubert, P., & Marin, M. (2001). What water will we drink tomorrow?International flagship.

Huot, A. (2010).*"Water and health"*, Bio magazine, contact, n°200, 2010.

J

John, P. and Donald, A. (2010). Microbiology, 3rd Edition, p1216.

Jora. (2011). Official Journal of the Algerian Republic Executive Decree No. 11-125 of 17 RabieEthani 1432 Corresponding to March 22, 2011 Relating, Quality of Water for Human Consumption, Official Printing Office, Orchards: Bir-Mourad Raïs, Algiers, Algeria, P: 7-25.

K

Kahoul, M and Touhami, M. (2014). Evaluation of the physicochemical quality of drinking water from the city of Annaba (Algeria). Larhyss Journal, ISSN 1112-3680, n°19, pp.129-138.

Kahoul, M., Derbal, N., Alioua, A., Ayad, W. (2014). Evaluation of the physicochemical quality of well water in the Berrahal region (Algeria). Larhyss Journal. ISSN 1112-3680. No. 18. Pp 169-1.

Kanohin, F., Otchoumou, E., Yapo, OB, Dibi, B., & Bonny, AC (2017). Physico-chemical and bacteriological characterization of Bingerville groundwater. International Journal of Biological and Chemical Sciences, 11(5), 2495-2509.

Kassou N. and Kacimi I., 2010. External geodynamics of groundwater course: Life and Earth Sciences sector. Univ. Mohammed V-Agdal.

Kirkpatrick. K, Fleming. E: Water quality, ROSS TECH 07/47, 12p, 2008.

Kouidri, B.Z. (2006). Study and treatment of water from the Djorf-Eltorba dam in the wilaya of Bechar by sand filtration. Master's thesis. Faculty of Sciences & Engineering Sciences. Hassiba Benbouali University. Chlef. Pp 18-20.

L

Lalanne, F. (2012). Study of water quality along the supply chain at consumer level in 10 villages in the Ganzourgou Province. (Central Plateau region, Burkina Faso). Pp 10

Lefèvre, D., &Andréassian, V. (2016). Water in danger?: a resource to be preserved on a daily basis.

Leyla, G and Ronnefoy, C and Guillet, F (2002). Microbiology and quality of the agri-food industries, Paris

Luc, J and Lagardette, M. (2009). Vademecum of water. Copyright Edition Johanet. Paris. ISBN:978-2-900086-82-7. Pp 66.

Luna B. And Kenneth S, (1972)."The water», Edition: Time-Life, P 9.

M

Maiga. (2005). Organoleptic quality of drinking water produced and distributed by the EDM. Sa in the city of Bamako: seasonal assessment. Doctoral thesis, faculty of medicine, pharmacy and odonto-stomatology Bamako, PP.17-21.

Malloum, MSA, Theophile, M., Tidjani, A., Ndoumtamia, G and Bichara, L. (2015). Evaluation of the physico-chemical quality of public water supply from the Société Tchadienne des Eaux in N'djamena, Chad. Journal of Applied Biosciences 95:8973 – 8980. ISSN 1997–5902. PP 8977.

Mazzuoli, L. S. (2012). Sustainable Management of Water Resources. Quality. Organization. 2nd Ed. Pp 60, 61,70.

Moletta, R.(undated document). Water, its pollution and its treatment. France

Molinie, L. (2009). Rustic drinking water supply and treatment devices for small-scale services in disadvantaged regions, Agro Paris Tech, Montpellier, Cedex 4, 7p.

Musy A. and Higy C., 2004. Hydrology. Ed Polytechnic and university presses, Romandes, Lausanne.

Myrand, D. (2008). Technical guide: groundwater collection for isolated residences, Quebec, P04.

NOT

Nouayti1, N., Khattach, D., Hilali, M. (2015). Evaluation of the physicochemical quality of groundwater from Jurassic aquifers in the upper Ziz basin (central High Atlas, Morocco). J. Mater.Approx. Sci.1068-1081. ISSN: 2028-2508. CODEN: JMESCN.

O

Federal Office for the Environment, Forests and Landscape (OFEFP). (2003). Groundwater, Federal Department of the Environment, Transport, Energy and Communications, 31p.

WHO. (1972). Drinking water quality guidelines. Geneva.

WHO, "Standards for surveillance of vaccine-preventable diseases".

WHO. (2004). Guidelines for drinking water quality.

WHO. (2005). Water safety plans, Management drinking water quality from catchment to consumer. Water, Sanitation and Health protection and the Human Environment, Geneva, Switzerland.

Ouahchia, C., Hamaidi-Chergui, F., Hamaidi, MS, Saidi, F. (2015). Bacteriological quality of drinking water from the various reservoirs and from consumers in the commune of Tipaza supplied by the Sidi Amar station from surface water from the Boukourdane lake-dam.Larhyss Journal. ISSN 1112-3680. No. 23. Pp 139-154.

R

Ramade, F. (1984). Elements of ecology, fundamental ecology. Ed. McGRAWN-HILL, 397 p.

Report on monitoring the quality of drinking water in Algeria (2008), National Institute of Public Health.

Fox, F. (2002). Hydrogeology course, Professional Master-DESS, 4-5P

Rodier. (1984).*Water analysis: Natural waters, Waste water, Sea water*, 7th

Rodier, J. (2005). Water analysis, Waste water, Sea water. 8th edition. Dunod. Paris, p.1383,1479.

Rodier, J., Legube, B., & Merlet, N. (2009). Water Analysis 9th edition. Fully updated, Dunod, Paris.

Rodier.J, Bazin.C, Broutin.J, Chambon.P, Chapsaup.H, Rodi.L.(1996).*Water analysis: Natural water, waste water, sea water*. 6th edition Dunod, 30-31,204-205,380-500,1086-1335p, Paris.

S

Sari, H. (2014): Contribution to the study of the physicochemical and bacteriological quality of spring water. Master's thesis, food sciences option. Abou Baker Belkaid Tlemcen University.

Savary, P. (2010). Guide to water quality testing. 1st Ed: Territal in Bresson.

Schoeller, H. J. (1975). Water Pollution. Underground. Proceedings of the Moscow Symposium; Proceedings of the Moscow Conference, IAHS-AISH Publ. No. 103.

Seghir, K. (2008). Vulnerability to pollution, protection of water resources and active management of the aquifer subsystem of Tébessa Hammamet (Eastern Algeria), Doctoral Thesis in Earth Sciences. Badji Mokhtar University, Annaba, Algeria. p158.

Sevesc. (2013). Water Service (SEVESC). Quality of drinking water leaving the Versailles and Saint Cloud drinking water treatment plant, 11p.

Simmons G., V., Hope, G., Lewis, J., Whitmore and W., Gao, (2001). Contamination of potable roof-collected rainwater in Unckland, New Zealand. Water Research (35): PP1518-1524.

T

Tchadanaye, NM, Nambatingar, N., Tchoroun, MD (2016). Physico-Chemical Quality of Consumer Waters in N'djamena. Human Journals. 5 (2). Pp 72.

V

Villers. J, Squilbin.M, Yourassowsky. C. (2005). Physicochemical and chemical quality of surface water. Brussels Institute for Environmental Management, Belgium.

Y

Youmbi, JGT, Feumba, R., Njitat, VT, de Marsily, G., &Ekodeck, GE (2013). Groundwater pollution and health risks in Yaoundé, Cameroon. Comptes Rendus Biologies, 336(5-6), 310-316.

APPENDICES

Annex I:Official Journal of the Algerian Republic (March 2011 executive decree n°14-96 relating to the quality of water for human consumption).

Table 01: Algerian drinking water standards

Settings	Unit	According to the Algerian Journal
Physico-chemical factors		
pH	-	6.5 – 9
Conductivity	µs/cm at 20°C	2800
Turbidity	NTU	5
Temperature	°C	25
Pollution factors		
Nitrites	mg/l	0.2
Ammonium	mg/l	0.5
Phosphate	mg/l	0.5
Bacteriological factors		
Total germs - 37°C 24h -22°C 72h	 No. / 100ml No. / 100ml	Not mentioned
Total coliform	No. / 100ml	0/100ml
Fecal coliform	No. / 100ml	0/100ml
Streptococci	No. / 100ml	0/100ml
*Clostridia*sulfate reducers	No. / 20ml	0/20ml

Appendix II: Enumeration of bacterial strains

Table 02: MacGrady Table**(**Most probable number and confidence interval 3-3-3)

Number of tubes giving a positive reaction on			NPP in 100 ml	Confidence limit at 95%	
3 tubes of 10 ml	3 tubes of 1ml	3 tubes of 0.1 ml		Lower limit	Superior Limit
0	0	1	3	< 0.5	9
0	1	0	3	< 0.5	13
1	0	0	4	< 0.5	20
1	0	1	7	1	21
1	1	0	7	1	23
1	1	1	11	3	36
1	2	0	11	3	36
2	0	0	9	1	36
2	0	1	14	3	37
2	1	0	15	3	44
2	1	1	20	7	89
2	2	0	21	4	47
2	2	1	18	10	149
3	0	0	23	4	120
3	0	1	39	7	130
3	0	2	64	15	379
3	1	0	43	7	210
3	1	1	75	14	230
3	1	2	120	30	380
3	2	0	93	15	380
3	2	1	150	30	440
3	2	2	210	35	470
3	3	0	240	36	1300

3	3	1	460	71	2400
3	3	2	1100	150	4800

Annex III: Composition of bacteriological culture media and reagents

1. Total and Fecal Coliforms

❖ **Bromocresol lactose broth (BCPL)**

➢ **Double concentration**

- Beef extract ……. 6gr
- Peptone……. 10gr
- Lactose …….. 10gr
- Bromocresol purple…….0.6gr
- Distilled water……..1000 ml
- pH: 6.7

Autoclaving: 20 minutes at 120°C

➢ **Simple concentration**

- Beef extract……3 gr
- Peptone…….5 gr
- Lactose……..5 gr
- Bromocresol purple……...0.03gr
- Distilled water……1000ml
- pH: 6.7

Autoclaving: 20 minutes at 120°C

❖ **Medium SCHUBERT (Indole - Mannitol)**

- Tryptophan……..0.2 gr
- Glutamic acid…… 0.2 gr
- Magnesium sulfate …… 0.7 gr
- Ammonium sulfate…… 0.4 gr
- Sodium citrate…….0.5 gr
- Sodium chloride……..2 gr
- Tryptoneoxoid……10 gr
- Mannitol……..7.5gr
- Distilled water……....500 ml
- Phosphate buffer pH 7.6 ……. 500ml

Autoclaving: 115°C for 10 minutes

➢ **Preparation of phosphate buffer**

- Distilled water ……500 ml
- Mono sodium phosphate……..1.44 gr
- Disodium phosphate ……9.21 gr

2. Fecal streptococci

❖ **ROTHE medium (glucose broth with sodium acid)**

➢ **Double concentration**

- Tryptone……40 gr
- Glucose……...10gr
- Sodium chloride…….. .10 gr

- Bipotassium phosphate…….5, 4 gr
- Monopotassium phosphate……5.4 gr
- Sodium azide……..0.4 gr
- Distilled water……..1000 ml
- pH: 6.8 -7

  Autoclaving: 15 minutes at 121°C

➢ **Simple concentration**

- Tryptonea…….....20 gr
- Glucose……5 gr
- Sodium chloride……..5 gr
- Monopotassium phosphate……2.7 gr
- Sodium azide……..0.2 gr
- Distilled water……1000 ml
- pH: 6.8-7

  Autoclaving: 15 mins at 121°C

❖ **EVA Letskey (Ethyl Violet Glucose Broth and Sodium Azide)**

- Tryptonea……. 20g
- Glucose……...5 gr
- Sodium chloride…….. . 5g
- Bi-potassium phosphate…… 2.7 gr
- Sodium azide…… 0.3 gr
- Ethyl violet……. 0.0005 gr
- Distilled water……..1000ml
- pH: 6.8-7

Noticed :

Colimetry media (BCPL, indole-mannitol medium) receive Durham bells during distribution.

Autoclaving: 15 minutes at 121°C

3. *Clostridium*sulfate reducers

❖ **Meat-liver agar (VF)**

- Meat Base - liver ……..20 gr
- Glucose…… 0.75 gr
- Starch…… 0.75 gr
- Sodium Sulphite……2 gr
- Citevetammonical iron……..... 0.5 gr
- Sodium carbonate …….0.67 gr
- Agar – agar……... 11 gr
- Distilled water ……...1000 ml
- Autoclaving 15 min at 120°C

4. Germ Totals

❖ **Tryptone-glucose-yeast extract agar (TGEA)**

- Tryptone…….. 5 gr
- Glucose…… 1 gr
- Yeast extract……..25 gr
- Agar ……15 gr
- Distilled water……..10000 ml
- pH: 7

  Autoclaving for 20 minutes at 121°C

5. *E-coli*

❖ **Kovacs reagent**

- Paramythylaminebenzaldehyde……5g
- Iso-amyl alcohol ……. 75ml

Appendix IV: Water quality grid defined by the Joint Order of the Minister of Equipment and the Minister responsible for Regional Planning, Urban Planning, Housing and the Environment n°1275-01 of 10 Chaabane 1423 (October 17, 2002).

Table 03: The different suitability classes for use in the production of drinking water

Quality class	Excellent	Good	Average	Bad
Physico-chemical factors				
Temperature	<20	20-25	25-30	30-35
Conductivity	<750	750-1300	1300-2700	2700-6240
pH	6.5-8.5	8.5-9.0	<6.5 and >5.5 or 9.0 and 9.5	<5.5 or >9.5
Turbidity	<5	5	5-7	>7
Pollution factors				
Nitrite NO2-	<0.2	0.2-1	1-4	<4
Phosphate PO43-	<0.5	0.5-1	1-2	>2
Ammonium NH4+	<0.5	0.5-2	2-4	> 4
Bacteriological factors				
Coliform Bacteria	<50	50-5000	5000-50000	>50000
Escherichia coli	<20	20-2000	2000-20000	>20000
*Streptococcus*fecal	<20	20-1000	1000-10000	>10000
*Clostridia*sulfate reducers	0	0	0	0
Total germs - 37°C 24h -22°C 72h	 <10 <100	 10-100 100-1000	 100-1000 1000-10000	 >1000 >10000

-The “blue” suitability class: Water of very good quality requiring control only (European Council Directive 98/83/EC of November 3, 1998 relating to the quality of water intended for human consumption).

-The “green” suitability class: Water of good quality and acceptable for consumption requiring simple physical treatment and disinfection (European Council Directive 98/83/EC of November 3, 1998 relating to the quality of water intended for consumption human).

-The “yellow” suitability class: Water of average quality (non-potable water) requiring corrective physical and chemical treatment and disinfection to make it compliant with drinking standards (European Council Directive 98/83 of November 3, 1998 relating to the quality of water intended for human consumption).

-The “red” suitability class: Water of poor quality (water unsuitable for the production of drinking water) requiring extensive physical and chemical treatment, refining and disinfection operations (European Council Directorate 98/83/EC of November 3, 1998 relating to the quality of water intended for human consumption).

Résumé

L'eau potable est l'une des produits alimentaires les plus contrôlés. Elle doit être conforme aux normes de la qualité ; elle doit aussi répondre aux exigences de potabilité. Notre étude a porté sur l'évaluation de la qualité physicochimique et bactériologique des eaux souterraines. Pour apprécier la qualité de ces eaux, nous avons effectué un certain nombre d'analyses, sur plusieurs échantillons prélevés dans différents sites de la wilaya de Bouira.

Il en ressort selon les résultats obtenus que l'eau de Bouira analysée dans 12 sites (Puit YoftisKadiria, forage Said abid, source Thikentart, source Dechmia et source Ait laziz) sont de bonne qualité bactériologique et physicochimique et remplissent les critères de potabilité en se référant aux normes nationales et celles de OMS, Tandis que les autre sources (puit Tachemlit, puit Kalous, puit Mahouen, puit Merdja ,forage Ain bessam, forage Selloum et forage Sidi ziane) sont acceptables mais nécessitent une surveillance et un contrôle bactériologique et physique simple afin d'augmenter la qualité de potabilité.

On peut conclure que les eaux souterraines de la wilaya de Bouira sont de qualité physicochimique et bactériologique acceptable, pour la consommation humaine, mais cela nécessitant toujours une surveillance et un contrôle pour s'assurer de la potabilité et la qualité de différentes sources de l'eau, ce qui permet d'éviter toutes type des maladies hydriques, en protégeant la santé publique.

Mots clés : Bouira. Eau, Traitement, Qualité Physico-chimique, Qualité Microbiologique

Abstract

Drinking water is one of the most controlled food products. It must comply with quality standards; it must also meet potability requirements. Our study focused on the assessment of the physicochemical and bacteriological quality of groundwater in this region. To assess the quality of this water, we carried out a number of analyses on several samples taken from different sites in the city of Bouira (12 sites). It emerges according to the results obtained that the water of (YoftisKadiria well, Said abid borehole, Thikentart spring, Dechmia spring and Aitlaziz spring) are of good bacteriological and physicochemical quality and meet the criteria of potability by referring to national standards and those of world Health organization, While the other sources (Tachemlit well, Kalous well, Mahouen well, Merdja well, Ain bessam borehole, Selloum borehole and Sidi ziane borehole) are acceptable but require simple bacteriological and physical monitoring and control in order to increase the quality of potability.

It can be concluded that the groundwater of the wilaya of Bouira is of acceptable physicochemical and bacteriological quality, for human consumption, but this always requires monitoring and control to ensure the potability and quality of different sources of water, which helps to avoid all types of waterborne diseases, by protecting public health.

Keywords: Bouira. Water, Treatment, Physicochemical Quality, Microbiological Quality

الملـخـص

تعتبر مياه الشرب من أكثر المنتجات الغذائية الخاضعة للرقابة. يجب أن تمتثل لمعايير الجودة؛ يجب أن تلبي أيضًا متطلبات صلاحيتها للشرب. ركزت دراستنا على تقييم الجودة الفيزيائية والكيميائية والبكتريولوجي للمياه الجوفية في هذه المنطقة. ولتقييم جودة هذه المياه قمنا بعدد معين من التحاليل على عدة عينات مأخوذة من مواقع مختلفة في مدينة البويرة (12 مواقع). يتبين من النتائج التي تم الحصول عليها أن المياه من (بئر YoftisKadiria، بئر سعيد عبيد، مصدر Thikentart، مصدر Dechmia ومصدر Ait laziz) ذات نوعية بكتريولوجية و فيزيوكيميائية جيدة وتلبي معايير الصالحية للشرب بالرجوع إلى المعايير الوطنية وتلك أما المصادر الأخرى (بئر Tachemlit، بئر Kalous، بئر Mahouen Merdja، حفر Ain bessam حفرSidi ziane Selloum) فهي مقبولة ولكنها تتطلب مراقبة ومراقبة بكتريولوجية وفيزيائية بسيطة من أجل زيادة جودة الصالحية للشرب.

ويمكن الاستنتاج أن المياه الجوفية لولاية البويرة ذات نوعية فيزيائية وبكتريولوجية مقبولة للاستهلاك البشري، لكن ذلك لا يزال يتطلب المراقبة والمراقبة لضمان صلاحية ونوعية مصادر المياه المختلفة، مما يجعل من الممكن تجنب جميع أنواع الأمراض المنقولة بالمياه، مع حماية الصحة العامة.

الكلمات المفتاحية: البويرة المياه والمعالجة والجودة الفيزيائية والكيميائية والجودة الميكروبيولوجية.