Journal of Fundamental and Applied Sciences

Research Article

ISSN 1112-9867

Available online at http://www.jfas.info

WATER QUALITY CONTROL OF THREE SITES AT KEDARRA BARRAGE

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Received: 21 March 2021 / Accepted: 30 April 2021 / Published online: 01 May 2021

ABSTRACT

Study aim is to monitor water quality at three sites at Keddara barrage which located on territory of Boumerdes-Algeria. Physico-chemical, bacteriological and heavy metal analyses were carried out on waters feeding barrage site A, within barrage site B and those leaving barrage corresponding to pumping waters site C. Physical qualities of all three waters largely meet WHO standards. Chemical qualities Results showed that hardness is greater at site C. A mineralization with low nitrate, chloride, phosphate and ammonium contents. DCO/DBO5 ratio < 3 (for all three sites), indicating that source of water pollution is of organic origin. Analysis results of all three samples by SAA revealed traces of heavy metals which confirm good water quality. Keddara barrage waters are charged with total coliform bacteria, enterococcus and Escherichia-coli, so these waters require bacteriological treatment.

Keywords: Keddara barrage, Physical qualities, Chemical qualities, heavy metals, Microbiological quality.

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doi: http://dx.doi.org/10.43 14/jfas.v13i2.18

1. INTRODUCTION

Water has become a global strategic issue, management of which must imperatively be integrated into a political perspective of sustainable development. Indeed, some say that in third millennium, it will be as much a stake in wars as oil still is today [1]. Water isn’t a commodity like any other, but a heritage that must be protected, defended and treated as such [2]. Water is an essential element of biological life. Water use for food or hygiene purposes requires excellent quality, both physical and microbiological. Water intended for human consumption is potable only if it’s free of pathogenic germs such as bacteria, viruses and chemical substances such as nitrates, phosphates, heavy metals, pesticides, hydrocarbons in more or less long term, for individual’s health [3]. Water is considered as a common heritage for all humanity and man depends on it for his food and other activities. It’s found almost everywhere on earth and is vital for all life living organisms on earth. Nearly 70% of earth's surface is covered by water, mainly in oceans form [4, 5]. Water can be an ocean, a sea, a lake, a pond, a river, a stream and a canal. Water circulation within different terrestrial compartments is described by its biogeochemical cycle, water cycle (fig.1) [6].

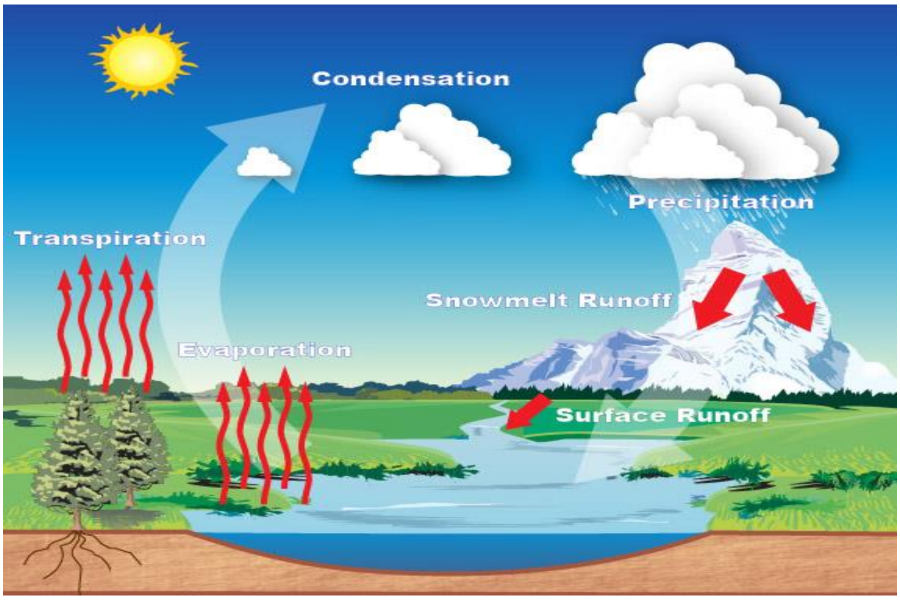

Fig. 1. The basic hydrologic (water) cycle [6]

Thus, and depending on raw water characteristics destined for drinking water production, specific treatments is most often necessary to meet regulatory requirements established by public health agencies [7,8]. In Algeria, raw water treatment plant for drinking water treatment is under increasing pressure to produce good quality drinking water at a lower cost. This represents a saving in terms of cost but also in terms of respect for environment [9,10]. According to forecasts of water demand at level of dwellings, industrial and tourist demand for entire Algerian territory by 2030 is estimated at 3.5 billion m^3 [11].

The aim of this study is to monitor water quality at three sites at Keddara barrage. Physico-chemical, bacteriological and heavy metal analyses were carried out on waters feeding barrage site A, within barrage site B and those leaving barrage corresponding to pumping waters site C. Heavy metals detection is also essential to determine waters quality.

2. RESULTS AND DISCUSSION

Water quality has become a major environmental and health concern. Drinking water must be based on three typical principles of parameters: physico-chemical, microbiological and absence of heavy metals toxic to health.

2.1. Physical quality

Temperature is a key physical parameter, in sense that it acts decisively on chemical and, even more so, biological processes within waterways [12]. Natural water conductivity should be between 50 and 1500 µS/cm [13]. Physical water quality results of three sites presented in Fig. 2. Study sampling analysis is carried out at three different sites: first site A corresponds to waters feeding barrage, second site B is within barrage and site C represents pumping waters pumping.

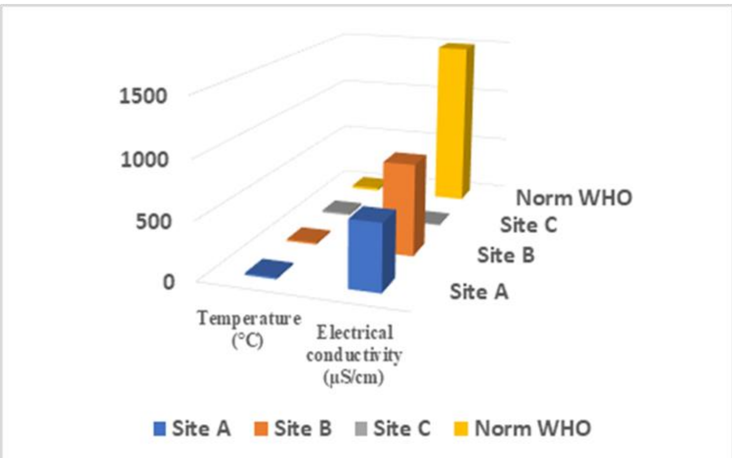

Fig. 2. Physical parameters measurement of Keddara barrage waters

Measured temperature values in three sites are significantly close. Therefore, temperature of these waters is almost stable and these values are below norm of 25 °C [10]. However, an increase in temperature is accompanied by an increase in saturation vapor pressure at surface (evaporation), and a decrease in gas solubility (oxygen). Increase of temperature favors development of micro-organisms thus consumption of oxygen and consequently reduction of dissolved oxygen content [14]. Regarding electrical conductivity, we found that water taken from site C presents a mineralization less than those of other sites. This is probably due to a slight increase in temperature at water pumping point [15]. Parameters temperature and electric conductivity results are correct and spread to standards for all sites.

2.2. Chemical quality

Results are presented in Table 1.

Table 1. Chemical parameters measurement of Keddara barrage waters

Parameter	Site A	Site B	Site C	Norme WHO [16]
pH	7.33	7.44	7.51	6.5-8.5
Turbidity (NTU)	250	393	10.7	5
TH (°F)	18	26	37.2	100-200
TAC (°F)	18.8	15.6	15.6	-
Nitrites (mg/l)	0.535	0.227	0.02	1
Phosphates (mg/l)	0.24	0.093	0.015	<0.5
Sulfates (mg/l)	109.9	161.25	-	400
Calcium (mg/l)	33.6	38.6	79.4	200
Chlorides (mg/l)	22.68	39.4	94.2	-
Magnesium (mg/l)	23.04	35.04	42	0.05
Nitrates (mg/l)	6.96	3.72	4.35	50
Manganese (mg/l)	<0.025	<0.025	<0.025	0.4
Ammonium (mg/l)	0.098	0.064	<0.015	0.045
DBO_5 (mg/l)	2.47	<0.5	1.2	5
DCO (mg/l)	<30	<30	42	50
MO (mg/l)	2.19	1.69	1.82	0. 07

pH

A water's pH is an indication of its tendency to be acidic or alkaline, and is a function of H^+ hydrogen ions activity in water. Results of pH values recorded for all three sites [7.33, 7.44 and 7.51] are well within WHO standards. pH value is right, especially at outlet barrage, so this water doesn’t need to be neutralized.

Turbidity

This is first parameter perceived by consumer. Turbidity is reduction of water transparency due to undissolved matter (organic debris, clays, microscopic organisms ...) [17].

According to results recorded in Table 1, we find an increase in turbidity at sites A and B with respective ratios of 250 and 393. And a drop of turbidity in site C with value of 10.7. But values are higher than standard, which is (5 NTU). Thus, we deduce that water at three sites is charged with suspended matter. This allows microorganisms to fix themselves on particles and very small particles of algae which are mainly found in barrage waters (site B) [18,19].

Hydrotimetric Title

According to obtained results, we notice that site C for water taken at pumping level has a significant hydrotimetric hardness of about 37.2 °F. This is due to its high calcium and magnesium content [20]. This means that site water C is hard according to to Boyd, C. E. [21].

Alkalometric title Complete

We registered a high TAC value at site A, this is due to its high content of OH^-, HCO_3^- and CO_3^{2-}. These are related by equation below:

$$TAC = [OH^-] + [HCO_3^-] + [CO_3^{2-}]$$

Since hydroxyl ion concentration for three sites ($7.33 < pH < 7.51$) is low compared to that of hydrogen carbonate ions and carbonate ions, in this case TAC will becomes:

$$TAC = [HCO_3^-] + [CO_3^{2-}]$$

Nitrites

Nitrites come from ammonia oxidation. Their presence in water in large quantities degrades it and may affect health [22]. According to results, site A has a high concentration of nitrites compared to other water sampling sites. However, according to WHO standard, nitrites levels recorded for three sites don’t exceed 1 mg/L.

Phosphates

Salts may be present in water in varying forms and concentrations: phosphoric acid from phosphates plant effluents, phosphates from domestic wastewater, phosphates from steam boiler drains, polyphosphates and Hexameta-phosphate from cooling circuits [23]. From

Table 1, a progressive drop in phosphates levels from site A to site C can be noted. Nevertheless, phosphates concentration for all three sites remains below standard (< 0.5mg/L).

Sulfates

Natural waters practically contain sulphates, in very variable proportions. Their presence results from calcium sulphate solubility in gypsum rocks and from oxidation of sulphides spread in rocks. Treated water to aluminum sulphate added during treatment by measuring sulphates content before and after treatment and after coagulation, although a small fraction of SO_4^{2-} ions is entrained by adsorption with flock [24]. Results from all three sites are summarized in Table 1. Sulphates concentrations recorded remain below standard for all 3 sites (maximum acceptable concentration = 200 mg/L (SO_4^{2-}) and maximum allowable concentration = 400 mg/L (SO_4^{2-})).

Calcium

This is an earthy alkaline metal; a major component of water hardness [25]. Its content varies essentially according to nature of soil crossed [26]. Calcium is found in waters that have crossed limestone rocks. With magnesium, calcium is responsible for water hardness [27, 28]. In comparison with Algerian standards of potability fixed for calcium, i.e. 200 mg/L, calcium content from site A to site C meets standard but is insufficient for good quality of water.

Chlorides

Chlorides are widely distributed in nature, usually in form of salts of sodium (NaCl) and potassium (KCl). They are often used as pollution indicators [13]. In addition, they exist in all waters in variable concentrations. Chlorides content increases from site A to site C, this content is between 22.68 and 94.2 mg/L. However, it remains below both maximum acceptable concentration (200 or 117.5 mg/L) and maximum allowable concentration (500 mg/L) (Afnor standard T 90612) [29].

Magnesium

Magnesium is a significant element of water hardness; it gives an unpleasant taste to water [30]. According to Algerian drinking water standards for magnesium (150 mg/l) [31]. From our study we found that magnesium content increases from site A to site C. This increase doesn't exceed acceptable levels of magnesium and as this latter is a significant component of water hardness, results obtained confirm those of hardness of water from all three sites.

Nitrates

Nitrates are a final stage of nitrogen oxidation and are naturally found in groundwater [15]. Their natural concentrations don't exceed 3 mg/l in surface water and a few milligrams per liter in underground water.

Nitrates concentrations obtained are in trace amounts, with a maximum concentration of 6.96 mg/L recorded at site A. In this case, values obtained from all three sites are below WHO standard (50 mg/L).

Manganese

Manganese concentrations are at trace levels of 0.025mg/L and remain below WHO standard (0.4 mg/L).

Ammonium

Usually, deeper waters are poor in ammonium; however, those from soils rich in humic substances or iron are likely to present levels of 1 to 3 mg/l, but, more often than not, this presence is due to animal or human discharges, and this is why ammonium is a good indicator of surface or ground water pollution [32]. We have registered a decrease in ammonium concentration from site A to site C. This level remains lower than normal concentration found in surface water < 0.2 mg/L and can go up to 0.3 mg/L in anaerobic water.

DBO_5

This parameter measures oxygen quantity necessary for destruction of organic matter via aerobic oxidation phenomena. To measure, reference is made to oxygen quantity consumed after 5 days; this is DBO_5 [33]. Results showed that at (site A) DBO_5 content is significant compared to two other water sampling sites. This content decreases at (site B) and increases at (site C). In other terms, these waters taken from different points can be classified as follows:

- water from site A has a DBO_5 = 2.47 mg/L O_2 therefore, its quality is average.
- water from site B has a DBO_5<1 mg/L O_2 therefore, it represents excellent water quality.
- water from site C has a DBO_5 = 1.2 mg/L O_2 therefore, water quality is good [13,34].

DCO

As DCO is related to DBO_5, DCO can be achieved faster than DBO_5 and gives an idea of total organic matter present, even when microorganisms can't grow (presence of a toxicant for example), whereas DBO_5 only measures naturally biodegradable organic matter. This is why DCO values are necessarily higher than DBO_5 values. Based on our results, DCO values in both sites A and B are less than 30 mg/L, whereas DCO in site C is equal to 42 mg/L. However, values of DCO/DBO_5 ratio of all three sites are well < 3, indicating that Keddara barrage water pollution is of organic origin which is more or less biodegradable [13,35].

Organic Matter

We found that highest organic matter content is relative to site A and lowest value is relative to site B. In fact, all waters of all three sites present OM contents close to 2 and in accordance with Rodier's classification [10], these waters are suspected of bacteriological or chemical contamination. This confirms results obtained for DCO and DBO_5.

Heavy Metals

These last years are metal micropollutants that can contaminate water and aren't biodegradable [36, 37]. Heavy metals are natural metallic elements whose density exceeds 5 g/cm^3. These are most often in trace amounts in our environment. Despite their trace presence, they can cause disease and constitute a health problem because of their toxicity and bioaccumulative nature [38, 39]. They are mercury (Hg), lead (Pb), cadmium (Cd), zinc (Zn), copper (Cu), arsenic (As), nickel (Ni), cobalt (Co), and manganese (Mn). The most toxic of these are lead, cadmium and mercury. Iron is abundant in rocks, dissolved iron precipitates in oxidizing medium. Its presence in water can promote proliferation of certain strains of bacteria [40]. Iron remains a safe metal, it allows oxygen to be fixed to human cells. Lead can cause delays in children's intellectual development and behaviour [41, 42].

Water can become contaminated with lead as it is transported to tap water and when it comes into contact with materials in distribution systems [43]. According to Baize [44], zinc and copper can become dangerous as soon as their concentration exceeds a certain threshold. Zinc can be adsorbed by suspended solids and sediments [45], but can become toxic at relatively low concentrations [46]. Parameters related to toxic substances: micropollutants such as arsenic, cyanide, chromium, nickel, selenium as well as certain hydrocarbons are subject to very strict standards because of their toxicity. Their tolerated content is around one millionth of a gramme.

Table 2. Heavy metal contents (by SAA) of Keddara barrage water

Heavy metal (µg/l)	**Site A**	**Site B**	**Site C**	**WHO** (mg/L)
Fe	18.66	20.97	45	0.76
Cu	2.95	3.279	50	2
As	0.443	2.201	52	0.01
Se	0.59	1.61	4.7	0.01
Pb	0.073	0.005	2	0.01
Zn	2.643	3.74	-	3
Mn	2.5401	3.625	< 20	0.4 ou 0.05
Cr	0.156	0.228	< 2	0.05
Cd	0.008	0.09	-	0.003
Ni	0.997	0.468	-	0.02
Co	0.146	0.088	-	-
Mo	0.754	0.644	-	0.07
Ba	86.261	72.588	50	0.7

Using data from Table 2, we have been able to represent heavy metal contents for each site, compared with those of WHO in fig. 3. Contents of iron, copper, arsenic, selenium, lead, zinc, manganese, chromium, cadmium increase from site A to site C. These contents don’t exceed WHO standards, but remain a danger to human health, as their bioaccumulation in organism causes its toxicity [47]. A decrease in nickel, cobalt and molybdenum grades from site A to site C is also recorded, with a slight difference between these grades. Concerning Barium contents, all three sites' waters are loaded with this metal with levels > 50 µg/L; but they remain below WHO's recommended standard, which is around 0.7 mg/L.

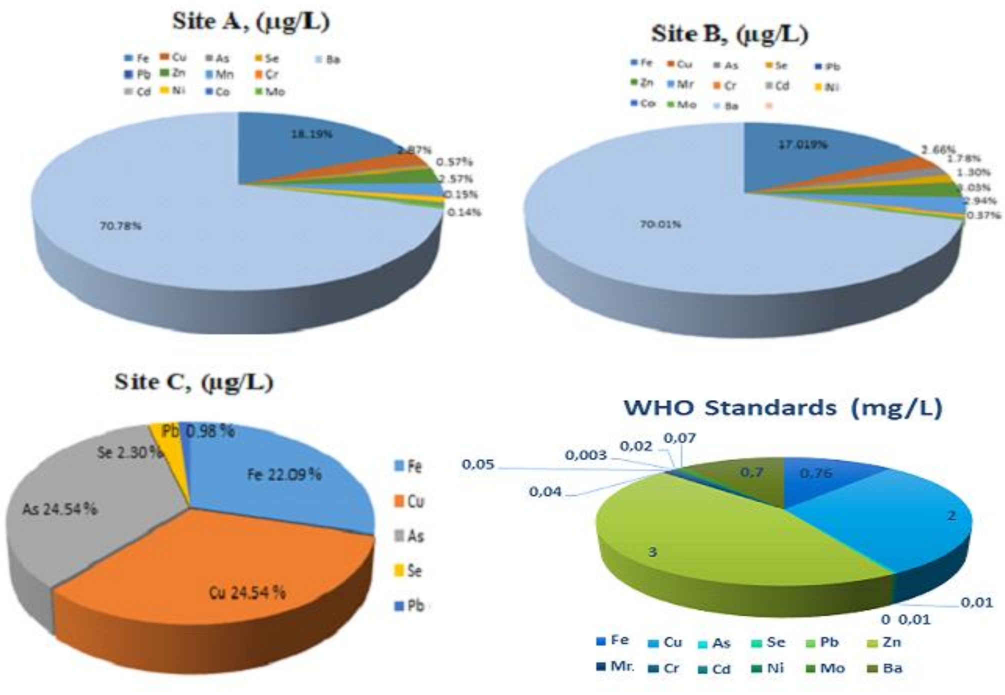

Fig. 3. Heavy metal content for each site and compared with WHO standards

Microbiological quality

Objective of water microbiological examination is to provide information about its potability, i.e. its risk of ingestion of disease-causing microorganisms. Escherichia-coli is a main coliforms representative [48,49]. Microbiological parameters: they allow to control that water is free of pathogenic germs, such as viruses, bacteria or parasites, which can cause diseases or even epidemics [50-52].

Table 3. Microbiological Quality Measurement of Water Keddara barrage

Bacterium	Site A	Site B	Site C
Total Coliforms (germ/100 mL)	>2419	>2419	>2419
Escherichia-coli (germ/100 mL)	325	257	183
Enterococcus (germ/100 mL)	>2419	>2419	>2419

Total Coliforms and Enterococcus

Total coliforms are considered indicators of water microbial quality because they can be indirectly associated with pollution of faecal origin [53]. Keddara barrage waters are loaded with total coliform bacteria and enterococcus, so these waters require bacteriological treatment.

Escherichia-coli

According to our study we notice, presence of Escherichia-coli in Keddara barrage waters. So, WHO standard advocates total absence of bacteria (total coliforms and enterococci and Escherichia coli).

3. EXPERIMENTAL

3.1. Geographical location

Keddra Barrage is located on territory of Wilaya of Boumerdes, 8 km South of Boudouaou and 35 km East of Algiers (Fig. 4). Wadi Keddara, at site right and after its confluence with Wadi EL Haad, takes its name Wadi Boudouaou, but this site is, however, generally called Keddara. This barrage closes valley of wadi Boudouaou at the end of mountainous course of Keddara wadi, a little before outlet of this one in Mitidja plain and immediately after its confluence with EL Haad wadi. It's here that crosses a recent narrowing in crystallophyllian terrains of Kabylia's western extension of metamorphic Kabyle massif, terrains which are anti Devonian in age. Gallery Hamiz-Keddara is a transfer structure built between reservoir of Hamiz barrage, established on Arbatache wadi, and valley of EL Haad wadi [54].

Fig. 4. Geographical location KEDDARA barrage

3.2. Destination

Keddara barrage is part of Isser-Keddara development. This project is intended to meet agglomeration's drinking water needs and will increase previously available volume by about 150×106 m^3/year. Keddara reservoir is fed by contributions from Keddara and EL Haad wadis and by a transfer gallery coming from Hamiz reservoir; in a new phase, it will also be fed by contributions coming from Isser wadi [54].

3.3. Water samples analysis

1.5 liters of water samples were collected from each site of three water sources for analysis at SEAAL laboratory. Unstable parameters such as pH, temperature and electrical conductivity must be measured in situ at sampling point. pH and temperature were measured using a potentiometric method using a platinum electrode in combination with a temperature probe. In contrast, electrical conductivity was measured directly with conductivity meters. Determination of bicarbonate concentrations (HCO_3^-) and hydroxide (OH^-) ions present in water was carried out by titration of hydrochloric acid necessary to bring pH to 8.4 (calculation of alkalometric title TA), and 4.5 (calculation of total alkalometric title TAC) of sample to be analyzed. TA and TAC, expressed in °F, are given respectively by means of these expressions:

$$TA = V_1 \times 10\ °F \qquad TAC = V_2 \times 5\ °F$$

With V_1 and V_2 are respectively volumes of hydrochloric acid read from the Dosimat to bring pH to 8.3 and 4.5. It’s essential to check water turbidity and NTU turbidity value is read on display of HACH 2100N IS TURBIDIMETER. Nitrates determination was carried out by spectrometric method with sodium salicylates. Reading was carried out with a spectrophotometer at a 420 nm wavelength. All calibration solutions must be prepared just before measurement. Calcium was determined by EDTA complexometric method. Ammonium determination in drinking water, raw water and waste water is based on molecular absorption spectrometry. Spectrometric measurement of blue compound formed by ammonium with salicylate and hypochlorite ions in presence of sodium nitroprusside.

Sulphates are determined by molecular absorption spectrophotometry after obtaining an opaque white precipitate due to $BaSO_4$. Spectrophometric measurement is at 420 nm wavelength, once standard solutions are prepared. Determination of chloride concentration in mg/l in given sample was carried out by silver nitrate ($AgNO_3$) titration using potassium dichromate (k_2CrO_4) as indicator. Chemical Oxygen Demand was determined according to ISO 6060. Biochemical Oxygen Demand DBO_5 is measured using an Oxitop instrument. After Day 5, results read on scale must be multiplied by conversion factor to get oxygen consumption is in mg /L. Nitrites analysis is adapted by using a dosed addition method and according to a reaction called diazotization (detection limit ≈ 1µg/L nitrite ions). It's applicable directly to samples with a nitrite ions mass concentration of less than 1 mg/L. Phosphate ions determination is obtained by following different steps of analysis with DosiCapZip. Heavy metal detection in water samples is obtained by atomic absorption spectroscopy using ZEEnit. Detection and enumeration of Escherichia coli and coliform bacteria (total coliforms) is done by membrane filtration according to NF EN ISO9308-1 standard.

4. CONCLUSION

In nature, water is a true source of life, but it can carry many diseases, some of which can be fatal. Surface water exploitation forces us to treat these waters to make them drinkable while preserving their physicochemical and bacteriological qualities. Water is an element that must be continuously monitored, because pollution makes it a vector of dreadful diseases and epidemics that are difficult to control. Our study focused on monitoring physico-chemical and bacteriological quality of samples. Results obtained during our study have led us to draw conclusions as follows:

- Parameters temperature and electric conductivity results are correct and spread to standards for all sites,
- All chemical parameters are in accordance with standards,
- values of DCO/DBO_5 ratio of all three sites are well above three (3), indicating that Keddara barrage water pollution is of organic origin which is more or less biodegradable,
- heavy metal content all results are well below standards, but remains a danger to human health because their bioaccumulation in body leads to their toxicity, With respect to barium concentrations, waters at all three sites are charged with this metal at

concentrations > 50 µg/L; however, they remain below WHO's recommended standard of approximately 0.7 mg/L,

- According to our study, we find Escherichia-coli in Keddara barrage waters. Thus, WHO standard recommends total absence of bacteria (total coliforms and enterococci and Escherichia coli), so these waters require bacteriological treatment. it should be noted that Escherichia-coli rarely multiplies unless conditions of high temperature and presence of nutrients allow it. Escherichia-coli is sensitive to disinfection by chlorine, which quickly inactivates it.

5. ACKNOWLEDGEMENTS

The authors acknowledge SEAAL laboratory for analysis.

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How to cite this article:
Ghemmit-Doulache N, Ouslimani N. Water quality control of three sites at kedarra barrage. J. Fundam. Appl. Sci., 2021, *13(X), 965-981*.