



Physico-chemical and bacteriological analysis of water quality in different types of water from the Ain Zada Dam of Bordj Bou Arreridj (Algeria).

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ABSTRACT

Physico-chemical and microbiological characteristics of the water samples were analysed following the standard methods to evaluate the quality of drinking water from (Raw water, Water before treatment, Water after treatment, Tap water) at the Ain Zada Dam to Bordj Bou Arreridj (Algeria) were analyzed. The results revealed that the physico-chemical and hydrochemical characteristics: (Temperature, PH, Conductivity, TDS, Turbidity, Dissolved Oxygen, Dry Residue, Ammonium, Total Hardness, Calcium and Magnesium, Chloride, Bicarbonate, Alkalinity, TAC, Iron, Manganese and Aluminum were found within permissible limits for drinking water as prescribed by WHO especially tap and after treatment water. Pearson correlation analysis, conducted to evaluate the relationship of water quality parameters, revealed a significant positive relationship between Total hardness with each of DO, Nitrate, Chlorides, and temperature (0.979, 0.961, 0.941 and 0.973) and negative significance with most of other parameters. Calcium and Sodium were correlated positively with Sulfate (0.986, 0.602 respectively). The detection of *Total coliform*, *total germ*, *E. coli*, *Fecal Streptococci* and *Clostridium Sulf-Red* species was intended for human consumption suggests that Raw water and Water before treatment pose severe health risks to consumers and was found unsuitable for direct human consumption without treatment. The present study recommends mobilization of treatment interventions to protect the households from further possible consequences of using the water.

INTRODUCTION

Water quality is the summation of all physical, chemical, biological and aesthetic characteristics of water that influence its beneficial use (Boyde and Craig, 2009). Water is vital and most essential commodity to the survival of life, where water is the source of all biological lives and their sustenance (WHO, 2011). Water is often used for domestic purposes especially for drinking. These different purposes have its own requirements for the composition and purity and each body of water has to be analysed on a regular basis to confirm the suitability (Nidhi Saxena *et al.*, 2011). Rapid urbanization and industrialization of society have resulted in high use of fertilizers for intensive agricultural production.

Moreover, water bodies have been affected by excessive nutrient inputs as a result of enhanced human activity and extended wastewater generation. This is causing water eutrophication, which is a critical issue throughout the world (Bloem *et al.*, 2017). Therefore, it is of major importance not only to have an adequate and accessible supply, but also to have quality water that is considered safe for human consumption (Amanatidou, *et al.*, 2007). It is seriously affecting water quality, thus resulting in restriction of human drinking water supplies and deteriorating dissolved oxygen in water bodies, which is a danger for aquatic organisms (Carey and Migliaccio, 2009). Water for human consumption is supposed to be free from chemical substances and microorganisms which may cause disease in man. In addition, it should be pleasant to drink. That is, cool, clear, colorless and devoid of disagreeable taste or smell; water is said to be contaminated or polluted when it contains infective and parasitic agents, poisonous chemical substances, industrial wastes or sewage that make it unfit for its intended use (Arora, and Arora, 2008). Human activities in many parts of the world, e.g., animal production, still impact negatively on the environment and biodiversity. Some of the consequences of man-made pollution include transmission of diseases by water borne pathogens, eutrophication of natural water bodies, accumulation of toxic or recalcitrant chemicals in the soil, destabilization of ecological balance and negative effects on human health. So, its importance in our daily life makes it imperative that thorough microbiological and physio-chemical examinations be conducted on water (Lamikanra, 1999). Water quality is highly dependent on physical, chemical and microbiological conditions. The natural water analysis for physical, chemical and bacteriological properties including trace element contents are very important for public health studies. These studies are also a major part of pollution studies in the environment (Aminur Rahman, 2015). The water shortage in Algeria is on the way to become a crucial problem. Comparing to the needs of the population is increasing and is likely to rise in the future due to the impact of climate change and pollution as reported by many authors (Reichwaldt and Ghadouani, 2012; Saoudi *et al.*, 2017).

In Algeria, several reservoirs and dams are experiencing in recent years problems of degradation of water quality due mainly to the different sources of pollution (Boudoukha and Boulaarak, 2013; Guizani *et al.*, 2016; Sakhel *et al.*, 2017), due to population growth, the expansion of the industrial fabric and agricultural development. This often discharges from urban areas directly in streams without any treatment due to the lack of regulatory and remediation frameworks at the area (Bain *et al.*, 2014). In the high plateaus region of Sétif, a large industrial, agricultural and urban activity develops throughout the entire Oued Bousselem watershed. The main river receives daily hundreds of cubic meters of waste that generate a total deterioration of the quality of surface waters in the region (Mebarkia *et al.*, 2017). The dam of Ain Zada is located on the high plains of Sétif at 815 m above sea level. The surface of the catchment area is approximately 2080 km² (ANB BBA, 2013). It is supplied by three main valleys: Bousselem (with industrial discharge), Malah, and Ain Taghrout (with urban water discharge). The dam water is used for drinking water supplies, for irrigation, and as an extensive aquaculture of the royal carp (*Cyprinus carpio*). The water body of Ain Zada displayed different responses to abiotic factors (Saoudi *et al.*, 2017). The water body of Ain Zada displayed different responses to abiotic factors. Ain Zada is considered an ancient dam, and is characterized by a large volume of 120 million m³, as well as low rainfall, which results in a slow renewal time. These conditions favor the development of the cyanobacteria as the only phytoplankton group in this dam (Saoudi *et al.*, 2017). For the rest of the year, the

region is subject to an irregular hydrological regime for the leaching of soluble chemicals, especially fertilizers and sewage from cities and urban centers with a mean annual flow of $0.42 \text{ m}^3/\text{s}$ measured at Farmatou station (Mebarkia, 2011). This enables the reservoir to receive a large share of annual liquid flow in few weeks and then it becomes finally stagnant water where evaporation is the dominant factor (Mebarkia *et al.*, 2017). Therefore, adequate attention should be given to this source of water. It becomes imperative that the water meant for human consumption should be free of diseases causing germs and toxic chemicals that pose a threat to public health. Hence the objective of the present study is to determine selected physical and chemical parameters (Temperature, PH, Conductivity, TDS, Turbidity, Dissolved Oxygen, Dry Residue, Ammonium, Total Hardness, Calcium and Magnesium, Chloride, Alkalinity Bicarbonate, TAC, Iron, Manganese and Aluminum) as well as Bacteriological analyses in the different types of water from Ain Zada Dam to Bordj Bou Arreridj (common Ain Taghrout). The obtained results were compared to the National and World Health Organization (WHO) water quality standards.

MATERIALS AND METHODS

Study area

The present study was conducted in the Ain Zada Reservoir ($05^{\circ} 80' 36'' \text{ N}$, $40^{\circ} 18' 05'' \text{ E}$), a big dam located in a semiarid region in the Bou Sellam basin (Fig. 1), northeastern Algeria (Bordj Bou Arreridj City), 25 km west of Setif and 40 km east of Bordj Bou Arreridj. It is locating on wadi Bou Sellem and drains the site of a 2080 km^2 watershed. It has a semi-arid climate and was constructed in 1986 with a dam height of 55 m. The area has a semiarid Mediterranean climate, characterized by a relatively winter temperate and also hot and dry summer, the rainy season runs among September and May, announcing the end of the wet season. The Bou Sellam basin is characterized too by an inter annual variability of rainfall, where we note that much of the rain falls in this region were during a few weeks in the form of downpour, then great droughts ahead after these downpours. The average annual rain falls vary between 300 and 700 mm. The Ain Zada reservoir is fed by Oued Bou Sellam, the reservoir stored a volume of water about 125 hm^3 and regulating a volume of 50 hm^3 per year to ensure the drinking and industrial water needs for the rapidly growing populations of Bordj Bou Arreridj and Setif cities (Mimeche and Biche, 2015; Ryma and Mouloud, 2018).

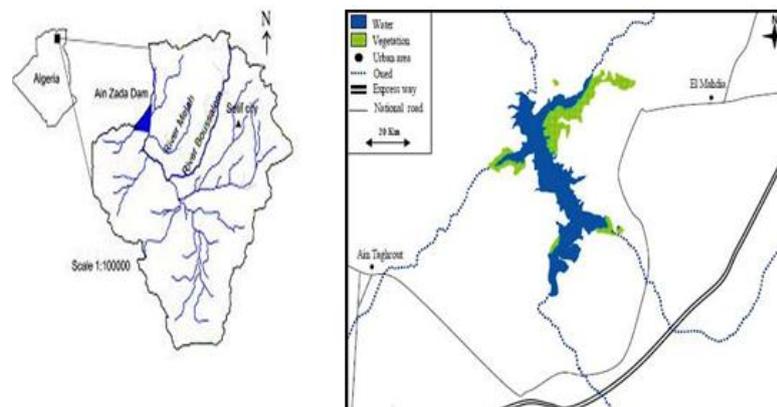


Fig. 1: Location of the study area.

Sampling

The water samples were collected from four locations (Raw water, Water before treatment, Water after treatment, Tap water) of Ain Zada dam from November 2013 to April 2014. All the samples were collected in sterilized and phosphate free bottle. The procedures for the analysis followed standard methods of analysis of water and waste water. All chemicals used were of AR grade and instruments used for study were of best quality and highest accuracy (WHO, 1993; APHA, 1998).

The physicochemical and bacteriological Analysis

The physicochemical and bacteriological Analysis of water was carried out at the Algerian Water Laboratory (A.D.E.) of Bordj Bou Arreridj (BBA). All chemicals used were of analytical reagent grade, and doubly distilled water was used in the preparation of all solutions in the experiments.

The physicochemical analysis

Several physical and chemical parameters were studied in the dam water at each station. Prior to analysis, all instruments were calibrated according to manufacturer's recommendations. The temperature of the water samples was determined by using a thermometer, pH was determined using the ODYSSEY pH meter (model DR / 2500), which was used after it was calibrated with standard buffers 4.0, 7 and 10. Conductivity was determined using ODYSSEY portable conductivity meter. Total suspended solids, total dissolved solids and Dissolved Oxygen were estimated by TDS ODYSSEY meter (Trivedi, 1997). Determination of turbidity was done using Turbidimeter, in Nephelometric turbidity units (NTU). The chloride content in water was determined by volumetric titration using standard solution of silver nitrate (0.1molL^{-1}) with potassium chromate (K_2CrO_4) as an indicator (More's method) (Waters-Doughty, 1924; AOAC, 1984). A spectrophotometer ODYSSEY (Model DR / 2500), with 1 cm matching quartz cells were used for the absorbance measurements and then reads spectrophotometer at 420 nm. Dry residue concentration determined by heating the samples at an oven at 105°C , for 24 hour, leave to cool for 15 minutes in the desiccator, weigh immediately and quickly, the results are given in mg / L.

Ammonium was determined by continuous flow method. The result is a greenish color that appears after one and half hour and indicates the presence of NH_4^+ . A quantitative analysis is carried out by UV spectrophotometer at 655 nm. The results are given directly in mg /L. Alkalinity of water samples were determined volumetrically by strong acid titration method. Bicarbonates (HCO_3^-), TAC was determined by pH- metric method at the equivalent point (Zangen, 1962). Calcium (Ca^{2+}), Magnesium (Mg^{2+}) and Total Hardness (TH), were analyzed by the standard EDTA (0.01M) titration method. Erichrome Black T was used as an indicator. Then, the solution was titrated with EDTA, until the last reddish tinge disappeared (the solution is normally blue) (APHA, 1999). Trace heavy metals i.e Iron, Manganese and Aluminum contents were determined by standards prescribed by (APHA, 1998) using Atomic Absorption Spectrometer (Perkin Elmer model A Analyst400).

Bacteriological analysis

The membrane filtration method of water analysis was used. Membrane filter of 47mm and pore size $0.45\mu\text{m}$ were used according to recommendations by APHA – AWWA (1998). 100mls each of water samples from six boreholes and five streams were filtered and the bacteria isolated and identified using the methods described by (Cheesbrough, 2000; Okorafor *et al.*, 2012).

Statistical analysis

Pearson Correlation Matrix and One-way analysis of variance (ANOVA) was utilized to investigate the inter-relationships between physico - chemical parameters. Alpha value for confidence interval (5%). All statistical analyses of data were conducted using computer program: Stat Plus LE Analyst Soft Inc 6.3.0.0 and analysis tool pack in Microsoft Excel.

RESULTS AND DISCUSSION

Physicochemical parameters

Table 1 represents some physicochemical parameters of water samples collected from four locations (Raw water, Water before treatment, Water after treatment, Tap water) of Ain Zada dam during November 2013 to April 2014.

Table 1: The levels Physico-chemical parameters of the different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013- April 2014.

Parameters	Samples				Limits
	Raw water	Water before treatment	Water after treatment	Tap water	
Temperature °C	14.89	14.89	15.05	16.13	< 25
pH	7.87	7.88	7.47	6.74	6.5-8.5
Conductivity µs/cm	1262	1271	1273	1170	900
TDS (ppm)	560	558	580	577	1000
Dry residue	798	797	845	786	1000
Turbidity NTU	11.75	11.36	1.51	1.47	5
Dissolved Oxygen (mg/L)	4.65	4.63	6.16	8.16	< 4.3
Nitrate (mg/L)	2.52	2.52	2.89	3.23	50
Nitrite (mg/L)	0.193	0.19	0.003	0.01	0.01 – 0.1
Phosphate (mg/L)	0.32	0.31	0.02	0.03	0.1
Ammonium (mg/L)	2.65	2.64	0.01	0.02	0.5
Total Hardness (mg/L)	58.58	57.67	59.67	63.34	500
Calcium (mg/L)	41.3	41.3	42.41	40.96	100
Magnesium (mg/L)	31.44	31.42	32.05	32.47	50
Sodium	139	139	141	140	200
Potassium (mg/L)	7.6	7.6	7.4	7.1	12
Chloride (mg/L)	211.11	211.16	230.74	243.95	250
Sulfate (mg/L)	160.09	159.76	162.97	158.28	250
Bicarbonate HCO ₃ (mg/L)	203.8	203.8	184.9	162.4	400
TAC (mg/L)	16.71	16.71	15.15	13.3	50
Iron	0.27	0.27	0.11	0.1	0.3
Manganese	ND	ND	ND	0.018	0.1
Aluminum	ND	ND	0.007	0.09	0.2

ND= not detected

Water temperature and pH:

Temperature is an important parameter for aquatic environment; it is governed by physical, chemical and biochemical properties (Taiwo *et al.*, 2012). Temperature is the main factor which affects almost all physico-chemical equilibriums and biological reactions (Delpla *et al.*, 2009). It can influence the pH, dissolved oxygen, redox potentials and microbial activity (Park *et al.*, 2010). The obtained results showed that the temperature ranged between 14.89 to 16.13 °C (Figure 2). Arain *et al.*, (2009), reported that there is a close relation between the atmospheric temperature and water temperature, air temperature is one of the most important ecological factors which control the physiological behavior of the aquatic system and distribution of the microorganisms.

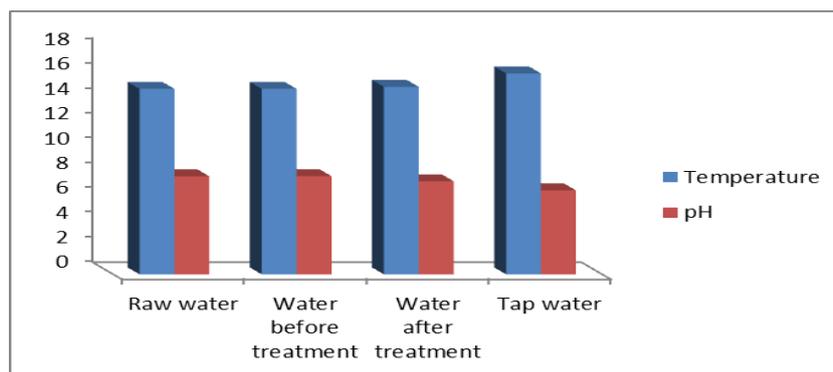


Fig. 2: Mean values of water temperature and pH from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April 2014

The pH of water is a reflection of the degree of acidity (pH lower than 7) or alkalinity (pH greater than 7). The fact that the pH of most unpolluted water lies between 6.5 and 8.5 pH is an important operational water quality parameter (WHO, 2011). The taste of water, its corrosiveness and solubility and speciation of metal ions are all influenced by pH. At low pH, water may taste sour while at high pH water taste bitter or soapy (DWA, 2006). The pH values didn't show fluctuations over the study period. In this research, the average of pH on the sampling sites was found between 6.74 and 7.87. The maximum pH value, 7.87, was recorded in the raw water source. The water pH values in most sampling points were found within the slight alkaline side (Fig. 2).

The pH value is influenced by the organic and inorganic compounds present in water. Any alteration in water pH is accompanied by the change in other physicochemical parameters. pH maintenance is one of the most important attributes of any aquatic system since all biochemical activities depend on surrounding water pH. Maximum values at raw water may be due to the increased in photosynthesis process of the algal blooms resulting into the precipitation of calcium and magnesium carbonates from bicarbonates causing higher alkalinity.

Conductivity, TDS and Dry residue

Conductivity, TDS and Dry residue at different sites were shown at Fig. 3. Conductivity is the electrical property of water, and depends on the ions present in the water – their concentration, mobility and the charge, as well as of the temperature at which the conductivity is measured. The maximum allowed value of conductivity of drinking water is up to 1000 $\mu\text{S cm}^{-1}$ (Nebojša Pantelić *et al.*, 2017). The minimum conductivity was measured in Tap water 1170 $\mu\text{S cm}^{-1}$ and the maximum in water after treatment 1273 $\mu\text{S cm}^{-1}$ (Figure 3). The obtained values were found above the

recommended value of WHO ($900\mu\text{s}/\text{cm}$), and SON ($1000\mu\text{s}/\text{cm}$) (WHO, 2004; SON, 2003). This measures the ability of water to conduct electricity which depends on the concentration of dissolved substances and temperature (Taiwo *et al.*, 2012, Roopavathi *et al.*, 2016).

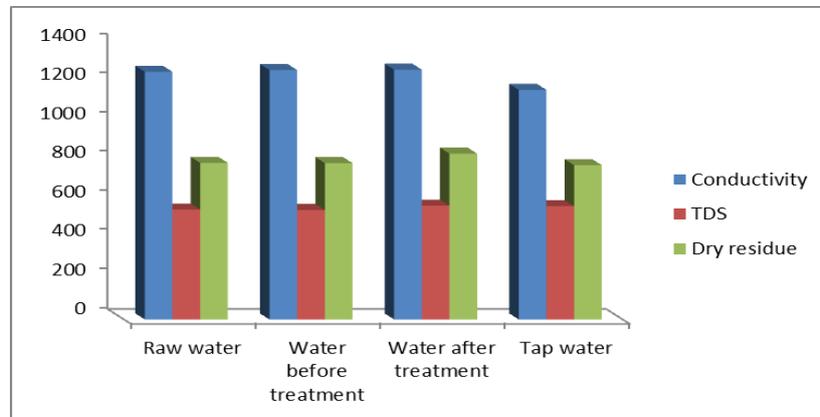


Fig. 3: Mean values of Conductivity, TDS and Dry residue from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014.

The level of TDS decides the quality of drinking water and since it is an important factor to aquatic life in keeping the cell density balanced. TDS and Dry residue of the samples ranged from 558 mg/L at Water before treatment - 580 mg/L at Water after treatment for TDS and from 786 mg/L at Tap water to 845 mg/L at Water after treatment. WHO is less than 1000 mg/L; Water with high TDS has normally affected the taste and causes the high alkalinity or hardness. The TDS concentration is a secondary drinking water standard, therefore, is regulated because it is more of a visual rather than a health hazard. The values of total dissolved solid and dry residue were considered high. These high values may be due to ground water pollution by waste waters which may originate naturally or introduced through human activities (Taiwo *et al.*, 2012).

Turbidity and Dissolved Oxygen DO

Turbidity in water is due to suspend and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms (Roopavathi *et al.*, 2016). The turbidity of the samples lies between 1.47 NTU to 11.75 NTU in the study area (Fig. 4). Maximum permissible limit of turbidity in drinking water is 5 NTU as suggested by WHO (2004), only raw water and Water before treatment samples exceed this limit.

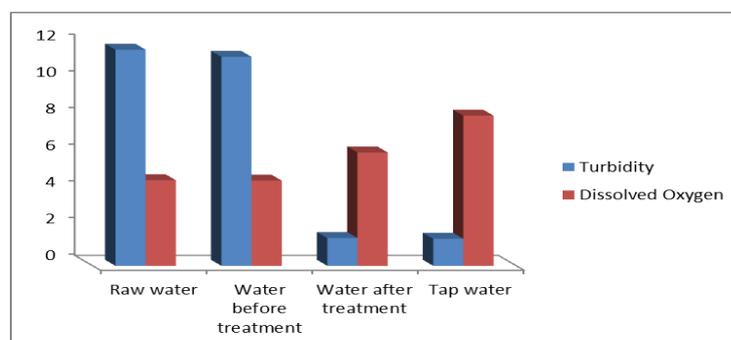


Fig. 4: Mean values of Turbidity and Dissolved Oxygen DO from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014

DO concentration is one of the most important parameter to indicate water purity. The importance of DO in aquatic ecosystem brings out various biochemical changes and it influence metabolic activities of organisms. In this research, the DO was found between 4.63 to 8.16 mg/L above normal of <4.3mg/L as recommended by WHO. The quantity of DO in water is directly or indirectly dependent on water temperature, partial pressure of air. Similar results were observed by Gulumbe *et al.* (2016) who reported that DO in water is largely dependent on important environmental factors like the temperature.

Nitrate and Nitrite

The presence of nitrates in water samples is suggestive of some bacterial action and other biological activities. Nitrate concentration in this research was found to vary from 2.52 to 3.23 mg/L (Fig. 5), which found within the 50 mg/L of WHO specification. Nitrate concentration depends on the activity of nitrifying bacteria which in turn get influenced by the presence of DO. This may be caused by the higher phytoplanktonic production, decaying macrophytes and concentration of nutrients due to the evaporation of water with subsequent increase in nitrate value. These facts have also been stressed by Majumder *et al.*, (2006); and Agarwal and Rajwar, (2010) in their observations. The decrease in nitrate content was probably due to its utilization as nutrient by the algal community as it has been evidenced by the massive growth of algae. Its value in the samples indicates pollution free, good water quality wise and suitable for drinking purpose.

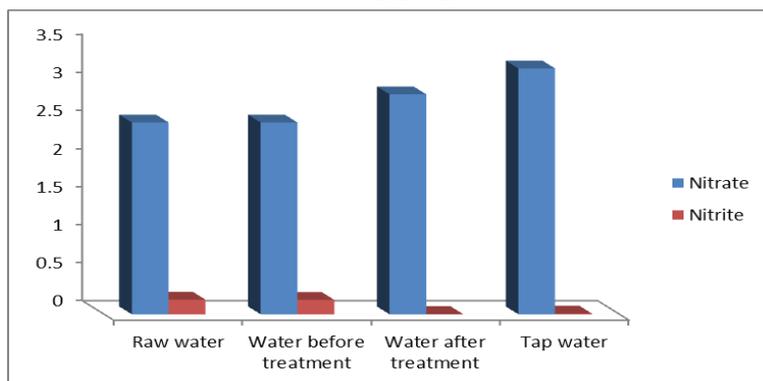


Fig. 5: Mean values of Nitrate and Nitrite from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014.

While the increase in the nitrite because either ammonium oxidation or reduction of nitrate by denitrification (Mebarkia *et al.*, 2017). All the water samples had traces of nitrite 0.003 - 0.193 mg/L (Figure 5).WHO required that Nitrite should be negligible because it forms N-nitroso compounds with Nitrogen in human stomach and accumulation of these act as potent carcinogens, Nitrite also has the ability to cause infant Methaemoglobin anaemia or blue baby syndrome (WHO, 1999).

Phosphate and Ammonium

During the present investigation, phosphate values were found between 0.020, 0.03 mg/L at treated and tap water to 0.32 mg/L at raw water as shown in Fig. 6. WHO (1993) has fixed it to be 0.1 mg/L. If level becomes too high, plant growth can accelerate resulting in the dense growth of algae and plants in the water body. Accelerated and uncontrolled plant growth impairs fishing, boating and other recreational uses of natural water (Choudhary *et al.*, 2014). The phosphate range in the Tap water of the present study was found within the permissible limit prescribed by WHO hence this water is suitable for drinking purposes.

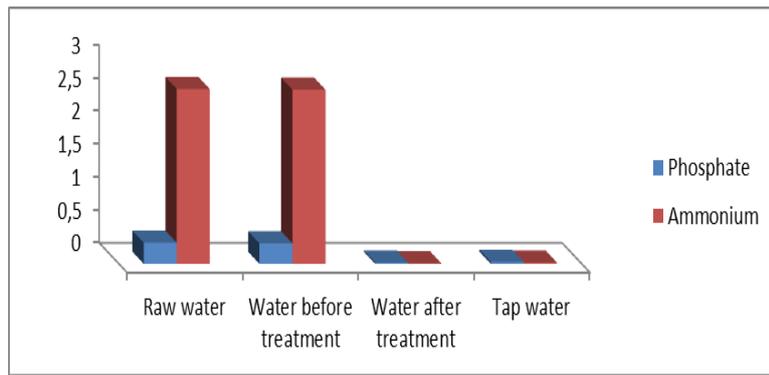


Fig. 6: Mean values of Phosphate and Ammonium from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014.

Ammonia is a biologically active compound found in most waters as a normal biological degradation product of nitrogenous organic matter (protein). In water ammonia reacts to form ammonium (NH_4^+) and hydroxyl (OH^-) ions. When the pH increase above 7.2, some free NH_3 remains and increases with increasing pH. It has been known that ammonia (NH_3) is toxic to fish and its toxicity increases with increasing pH and temperature of the water (Medeiros *et al.*, 2016). According to WHO, the maximum allowed presence of ammonia in drinking water is 0.5 mg L^{-1} (WHO, 1993). Only water samples from raw and untreated water contained higher level of ammonia (0.5 mg L^{-1}) while the values of the other samples were far below the maximum permissible value (Table 1).

Total Hardness, Calcium and Magnesium

The hardness of water is due to dissolved calcium and magnesium salts from soil and aquifer minerals containing limestone or dolomite (Roopavathi *et al.*, 2016). As in figure 7, the total hardness of the samples ranged between 57.67- 63.34mg/L, while WHO standards permit any value less than 500mg/L. In all samples of a study area, the total hardness were found not exceeded and beyond the maximum acceptable limit. Maximum permissible limit of calcium and magnesium in drinking water is 100mg/L and 50mg/L as suggested by WHO limit. In the area studied the content of calcium and magnesium in water ranged from 40.96 – 42.41 mg/L and 31.42-32.47 mg/L, respectively Fig. 7.

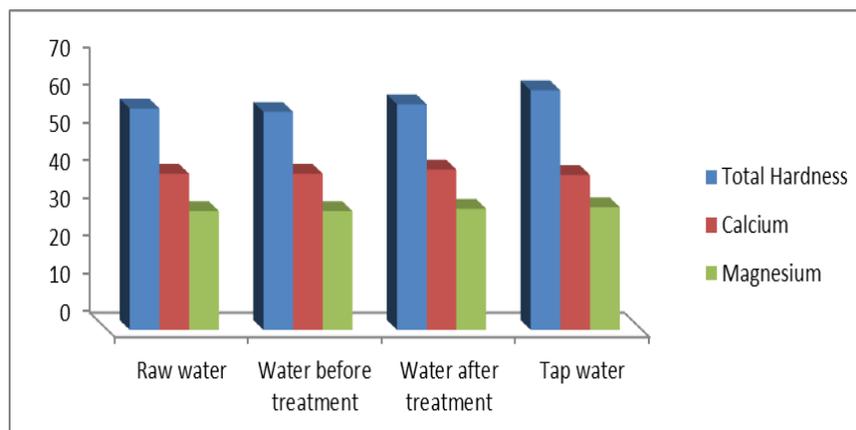


Fig. 7: Mean values of Total Hardness, Calcium and Magnesium from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014.

Both calcium and magnesium are essential for human body development and also for normal function. Inadequate intake of either nutrient can impair health.

Recommended daily intakes of each element have been set at national and international levels. As calcium is also a part of bones and teeth, it also plays a role in neuromuscular excitability (decreases it). Magnesium is essential as co-factor for enzyme activity including glycolysis, ATP metabolism, and transport of elements such as Na, K and Ca through membranes (WHO, 2009; Roopavathi *et al.*, 2016).

Sodium and Potassium

Potassium and sodium maintain the normal osmotic pressure in cells. Potassium is a cofactor for many enzymes and is required for the secretion of insulin, creatinine phosphorylation, carbohydrate metabolism and protein synthesis.

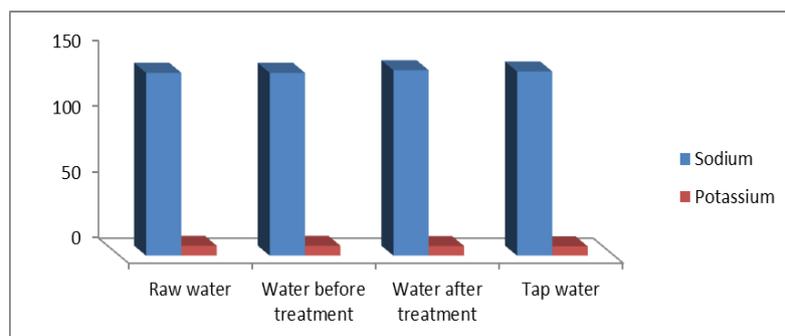


Fig. 8. Mean values of Sodium and Potassium from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014.

Minimum (139 mg/L) and maximum (141 mg/L) Sodium (Na) content was observed from raw and untreated water samples respectively (Table 1 and Fig. 8). The acceptable limit for Na is 200mg/L according to WHO limit (Table 2). Potassium is an important cation and plays a vital role in intermediately metabolism. K^+ is an essential nutrient for both plant and human life. Potassium (K) content of water samples varied from 7.1mg/L at Tap water to 7.6mg/L at raw water (Table 1, Fig. 8). All the water samples (100%) contained K content lower than permissible limit i.e. 20mg/L (Table 1). Sodium and Potassium affect on desirability, odor and taste of water (Rout, and Sharma 2011).

Chloride and Sulfate

Chloride values were found between 211.11 to 243.95 mg/L (Fig. 9) which is still below the WHO 250mg/L specification. Although the concentration is not high, it is an indicator of pollution due to organic waste of animal origin.

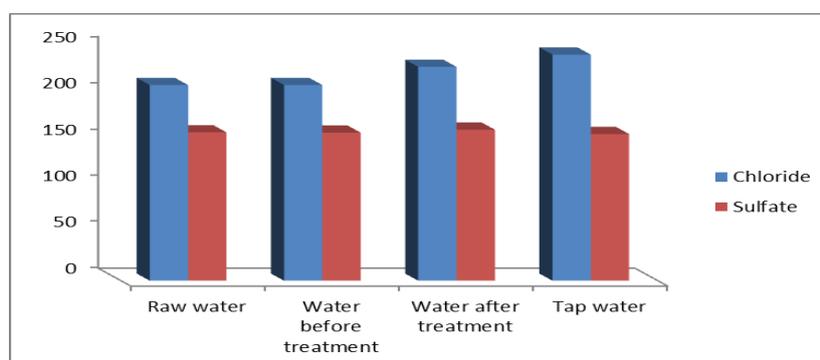


Fig. 9. Mean values of Chloride and Sulfate from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014

Sulphate is one of the least toxic anions of which WHO does not have any recommended value for drinking water, but catharsis, dehydration and gastrointestinal irritation have been linked to high sulphate concentrations in drinking

water (Gulumbe *et al.*, 2016). WHO (2011) therefore suggests an urgent action by health authorities when sulphate in drinking water exceeds 250mg/L. Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals (Kamal *et al.*, 2007). Discharge of industrial wastes and domestic sewage tends to increase its concentration (Gulumbe *et al.*, 2016). Concentration of sulphate in this research which ranged from 158.28 to 160.09 mg/L may be accompanied with the different types of water quality.

Bicarbonate and Total Acidity (TAC)

The Bicarbonate (HCO_3^-) ion is the principal alkaline constituent in almost all water supplies. Three carbonate species (H_2CO_3 , HCO_3^- and CO_3^{2-}) contribute to total alkalinity, their relative proportions being dependent on pH and temperature. At near-neutral values of pH, dissolved bicarbonate (HCO_3^-) is the dominant ion. The desirable limit of bicarbonate alkalinity in portable water is 400 mg/L, the minimum and maximum Bicarbonate values of water were observed on all sites, they found between 162.4 and 203.8 mg/L at Tap and Raw water respectively (Fig. 10). The bicarbonate alkalinity values of all samples were found within the permissible limit of 400mg/L (Roopavathi *et al.*, 2016).

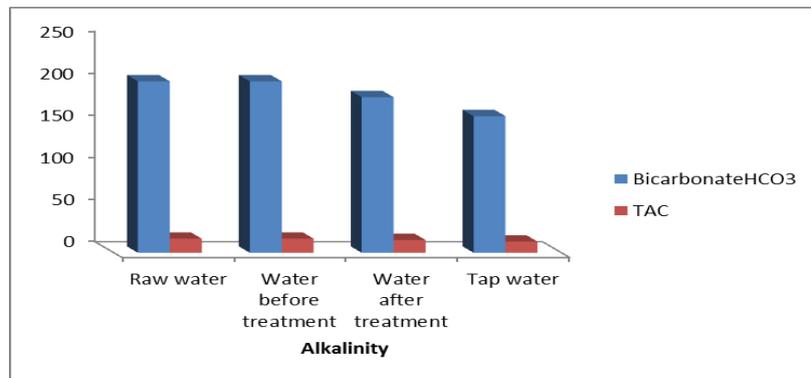


Fig. 10: Mean values of Bicarbonate and Total Acidity (TAC) from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April 2014.

Total acidity (TAC) values were observed, that ranging between 13.3 to 16.71 mg/L as CaCO_3 . All samples were found within the permissible limits of WHO limit (50mg/L). Hence the water must not be treated before its use for drinking and construction purpose.

Iron, Manganese and Aluminum

Iron and Manganese are an abundant metal found in the Earth's crust. It is naturally present in water but can also be present in drinking water from the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution. Iron is an essential element in human nutrition. WHO (2004) states that, values of up to 0.3mg/L. The studied sample ranged from 0.1 to 0.27 mg/L, so it do not present a hazard to health (EPA, 2014). High levels of manganese also cause objectionable tastes in the water but there are no particular toxicological connotations. The WHO recommends a guideline value of 0.1mg/L (Fig. 11). The average manganese of water in samples varied between below the limit of detection to 0.018 mg/L.

Aluminum is one of the trace inorganic metals present in drinking water. In addition to the naturally occurring Al in raw waters, use of Al-based coagulants often leads to an increase in treated water Al concentrations, though can be naturally present in some waters. WHO (2004) has proposed a guideline value of 0.2mg/L. Aluminum levels ranged between the below the limit of detection to 0.09mg/L in the

studied samples, which still lower than the permissible limits (Letterman and Driscoll, 1994).

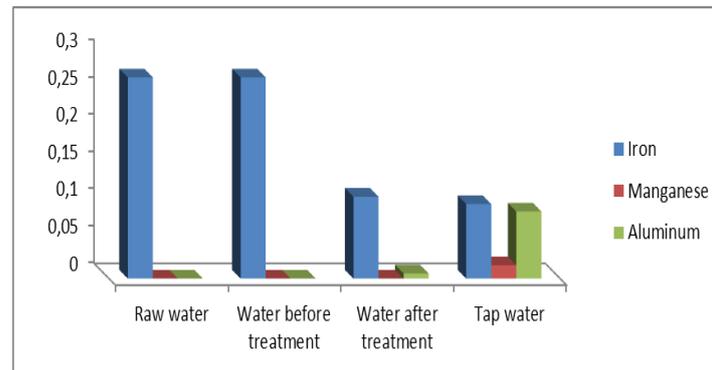


Fig. 11: Mean values of Iron, Manganese and Aluminum from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014

Physico-chemical Correlation

The correlation coefficient is commonly used to estimate the relationship between two variables. It is a simple statistical tool to show the degree of connection between the various variables. When, various water quality parameters of water samples were correlated (Table 2). At Alpha value for confidence interval (5%). Total hardness showed high significant positive correlation with DO, Nitrate, and temperature (0.979, 0.961 and 0.973) but negative significance with most parameters. TDS concentration is positively influenced by DO (0.812), Total hardness (0.723) and Nitrate (0.862) with significant. Chlorides is normally the most dominant anion in water it showed significant positive with Total hardness (0.941), magnesium (0.999), Sodium (0.708), and DO (0.985). TDS significantly correlated with DO (0.812) and Total hardness (0.723) but it also relate with Nitrate, phosphate and ammonium but they are insignificant. Calcium and Sodium positively correlated with Sulphate (0.986, 0.602) respectively.

Table 2: Significant correlation coefficients values among the physico-chemical water quality parameters at different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014

	pH	Temp.	Conduc	TDS	Dry residue	Turbidity	D.O.	Nitrate	Nitrite	Phosphate	Ammon	Total Hardness
pH	1.000											
Temp.	-0.971*	1.000										
Conduc	0.908*	-0.979*	1.000									
TDS	-0.764*	0.590*	-0.433	1.000								
Dry residue	0.182	-0.409	0.570*	0.492	1.000							
Turbidity	0.831*	-0.677*	0.524*	-0.988*	-0.393	1.000						
D. O.	-0.996*	0.950*	-0.872*	0.812*	-0.103	-0.873*	1.000					
Nitrate	-0.985*	0.917*	-0.823*	0.862*	-0.011	-0.914*	0.995*	1.000				
Nitrite	0.815*	-0.655*	0.500*	-0.993*	-0.420	0.999*	-0.858*	-0.902*	1.000			
Phosphate	0.816*	-0.657*	0.501*	-0.991*	-0.417	0.999*	-0.859*	-0.903*	0.999*	1.000		
Ammon	0.829*	-0.673*	0.521*	-0.991*	-0.398	0.999*	-0.870*	-0.912*	0.999*	0.999*	1.000	
Total Hardness	-0.987*	0.973*	-0.933*	0.723*	-0.239	-0.781*	0.979*	0.961*	-0.765*	-0.765*	-0.782*	1.000

Table 2 Continue

	Ca	Mg	Na	K	Cl	SO ₄	HCO ₃	TAC	Fe	Mn	Al
Ca	1.000										
Mg	0.015	1.000									
Na	0.717*	0.707*	1.000								
K	0.184	-0.979*	-0.552*	1.000							
Cl	0.016	0.999*	0.708*	-0.979*	1.000						
SO ₄	0.986*	-0.133	0.602*	0.329	-0.133	1.000					
HCO ₃	0.126	-0.989*	-0.601*	0.998*	-0.989*	0.273	1.000				
TAC	0.125	-0.990*	-0.601*	0.998*	-0.989*	0.272	1.000	1.000			
Fe	-0.311	-0.955*	-0.885*	0.876*	-0.955*	-0.164	0.903*	0.904*	1.000		
Mn	-0.561*	0.818*	0.174	-0.916*	0.817*	-0.678*	-0.891*	-0.891*	-0.611*	1.000	
Al	-0.497	0.859	0.247	-0.944*	0.858*	-0.621*	-0.923*	-0.922*	-0.669*	0.997*	1.000

*Indicates the significance ($p > 0.05$), without a star are near significant

Bacteriological analysis

An important indicator of water quality is the number of bacteria present in the water. Though it would be difficult to determine the presence of all bacteria in a sample, certain types of microorganisms can serve as indicators of pollution (Nkamare *et al.*, 2012). Chief among these are Total coliform, total ger, E. coli, Fecal Streptococci and Clostridium Sulf-Red were studied at different samples from the study area (Fig. 12).

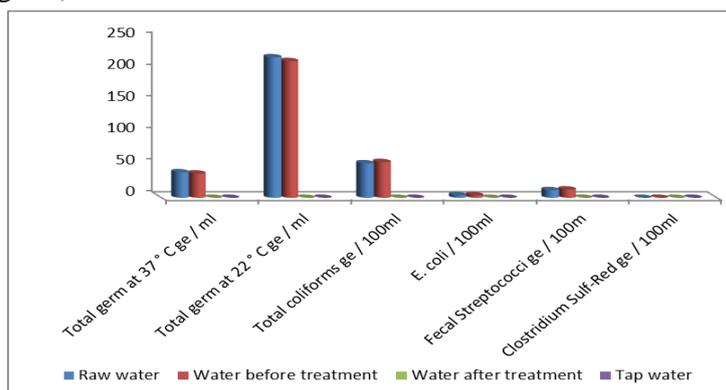


Fig. 12: Mean values of bacteriological count from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April 2014.

Not all bacteria present in water are harmful but it is the kind of specific microorganisms which are pathogenic cause water borne diseases. Their presence in water indicates contamination of water supply with fecal matter. Coliforms are the major microbial indicators for monitoring water quality. They are commonly found in intestinal tract of men and animals and considered as indicator organisms, used all over the world to establish the degree of faecal pollution in water (Singh *et al.*, 2017). From table 3, the results of bacteriological analysis after treatment and tap water appear consistent supplies of safe and wholesome water with low microbial load and do not need for another treatment of the drinking water (Deutsch, 2003). The zero (0) bacteriological count from after treatment and tap water may be due to routine treatment of such sources of drinking water. This result showed that these sites met the WHO standard for drinking water (\leq zero Cfu/100ml). The presence and high number of counts in raw and before treatment water samples analysed showed that there were focally contaminated (Okorafor, *et al.*, 2012).

Table 3: Mean values of bacteriological count from different types of water from the Ain Zada Dam to Bordj Bou Arreridj during Nov. 2013-April2014

bacteriological count	Samples				Limits
	Raw water	Water before treatment	Water after treatment	Tap water	WHO limit
Total germ at 37 ° C ge / ml	40	38	0	0	0
Total germ at 22 ° C ge / ml	220	214	0	0	0
Total coliforms ge / 100ml	54	56	0	0	0
E. coli / 100ml	4	4	0	0	0
Fecal Streptococci ge / 100m	12	13	0	0	0
Clostridium Sulf-Red ge / 100ml	0	0	0	0	0

CONCLUSION

The present work is an attempt to identify and assess different sources of contamination to drinking water. The physico-chemical analysis reveals the present status of drinking after treatment and tap water is suitable for drinking purposes except in raw water, Water before treatment. The quality of physico-chemical falls within the standard limits of WHO standards. Raw water and Water before treatment has been contaminated by microorganisms and they were bacteriologically unsafe for drinking purposes. Presence of coliform in drinking water supplies may be either due to contamination by sewage water through domestic and industrial sources. Water sources must be protected from contamination by human and animal waste, which contains hazardous microbes. A regular monitoring of water quality is needed to protect if further polluted. Water quality should be controlled in order to minimize acute problem of water related diseases, which are endemic to the health of man.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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