

Defluoridation by coagulation in drinkable water from the south east of Algeria

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ABSTRACT

The drinkable water in the south east of Algeria contains high quantity of fluoride which causes dental fluorosis. To decrease fluoride, we have chosen a sample with the biggest content of fluoride among many sources in order to coagulate it with $Al_2(SO_4)_3 \cdot 18H_2O$. After that the parameters influencing (concentration, pH, temperature) are studied to choose the best conditions for better reduction yield.

Keywords: Coagulation; Defluoridation; Fluorosis; Oasis water

1. INTRODUCTION

The water of the south east of Algeria is characterized by high concentrations of fluoride, associated with severely high and excessive total mineralization. This water is the only source of drinking. The hot and dry climate has forced people to consume a lot of water which leads to raise the daily consumption rate of fluoride. In addition the eating a lot of dates and tea leads to the spread of fluorosis disease [1] which is characterized by the yellowish of tooth enamel according to the classification of the national program of school health [2, 3]. To prevent these diseases from happening or reduce them, many techniques of defluoridation are used such as: membrane technologies, precipitation and adsorption. Our study is focused on adsorption with sulfate aluminium salt and determination of optimal conditions affecting the reduction of fluoride in drinking water.

2. EXPERIMENTAL SECTION

2. 1. Preparation of fluoride curve witness

To determine the concentration of fluoride in various samples, a potentiometer method was used (Rodier 2005) [4]. Different standard concentration solutions were prepared from NaF salt in cups of plastic. Then their potential is measured by using specific fluoride pole (ISE15381/1) and a pH-meter model (pH211), using a solution of TISAB⁽⁶⁾. The graph $E = f(\log C_F)$ is presented in Figure 1.

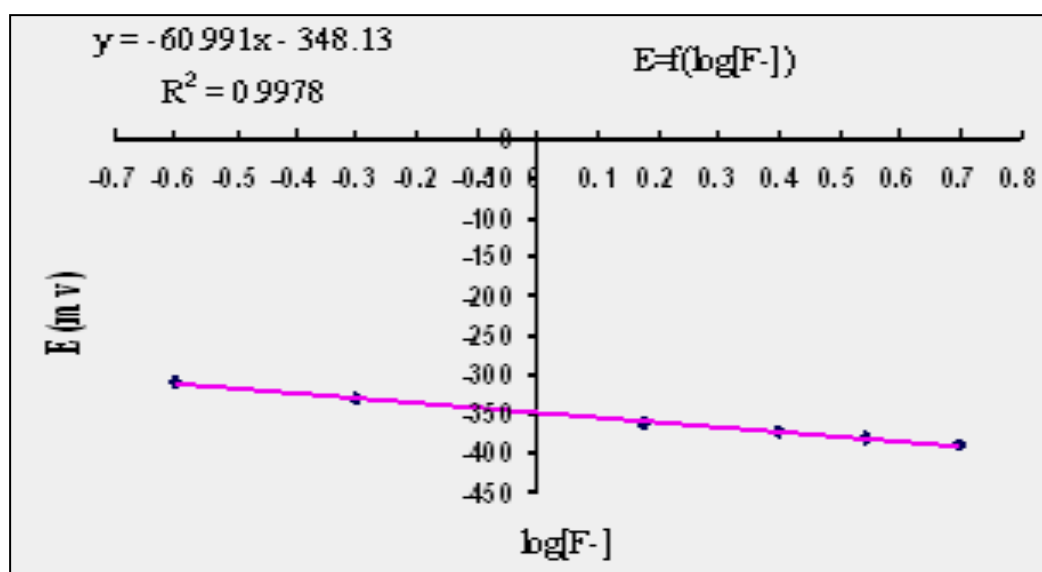


Figure 1. The witness graph for fluoride

2. 2. Determination of fluoride concentration in some samples of the study area

The concentration of fluoride has been determined in some water sources of the study area in order to determine and treat the largest content of fluoride. The results are presented in Table 1. The selected sample (cold water of Shuhada) has a concentration of fluoride 2.61 (mg / l).

Table 1. Fluoride concentration for some water in the studied area at T = 19.3 °C

Sources of water	mars city	mastur city	400 city	8may city	1Nov City	Nezla city	Shuhada
[F ⁻] (mg/l)	1.87	1.90	1.92	1.84	1.94	0.46	2.61

2. 3. Determination of the predominant concentration of ions in the studied water

The study was done according to (Rodier 2005) [4] on cold water of Shuhada as follows:

2. 3. 1. Nitrates and sulfates

Spectroscopy method (UV) ray using (spectrophotometer DR 2400).

2.3.2. Total hardness

By complexity with EDTA⁽¹⁾ in the presence of Eriochrome Black T at buffer solution of pH = 10.

2.3.3. Sodium and potassium

Using flame atomic absorption analysis. Results of Predominant ions are presented in Table 2.

Table 2. Physico-chemistry properties of Shuhada water.

Property	SO ₄ ²⁻	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	NO ₃ ⁻	TA	TAC	Cl ⁻
C (mg/l)	544	492	140	55	2.4	5.9	0	105	402

2.3.4. Alkalinity

Determining TA⁽⁴⁾ and TAC⁽⁵⁾ using PhPh⁽³⁾ and MO⁽²⁾ indicators respectively.

2.3.5. Chlorides

Volumetric method for Mohr.

2.3.6. Calcium concentration

By complexity with EDTA⁽¹⁾ in the presence of Murexide at a solution of pH = 12.

2.3.7. Magnesium concentration

Calculated from the difference Total hardness and Calcium concentration. The results are presented in Table 2.

2.4. Treatment

The factors affecting (mass, pH, and temperature T) were studied by the Coagulation method using Al₂(SO₄)₃·18H₂O with a purity of (98-100) % .

2.4.1. Effect of aluminium concentration

Based on the coagulation of fluoride on Al(OH)₃ according to equilibrium (1). 100 ml of Shuhada water was put in each cup of plastic then the pH and temperature T were measured, after that different amount of the same salt was added to each cup. After stirring for 3 minutes, they are left for a while then filtered, finally the amount of fluoride in the filtrate was measured. The results were presented in Table 3 and Figure 2.

Table 3. Relation between the added aluminium and the residual fluoride (pH = 7.30 and T = 21.2 °C).

[Al ³⁺] (mg/l)	2.0	2.4	2.8	3.2	4.0	4.8
[F ⁻] (mg/l)	1.79	1.57	1.41	1.28	1.09	0.96

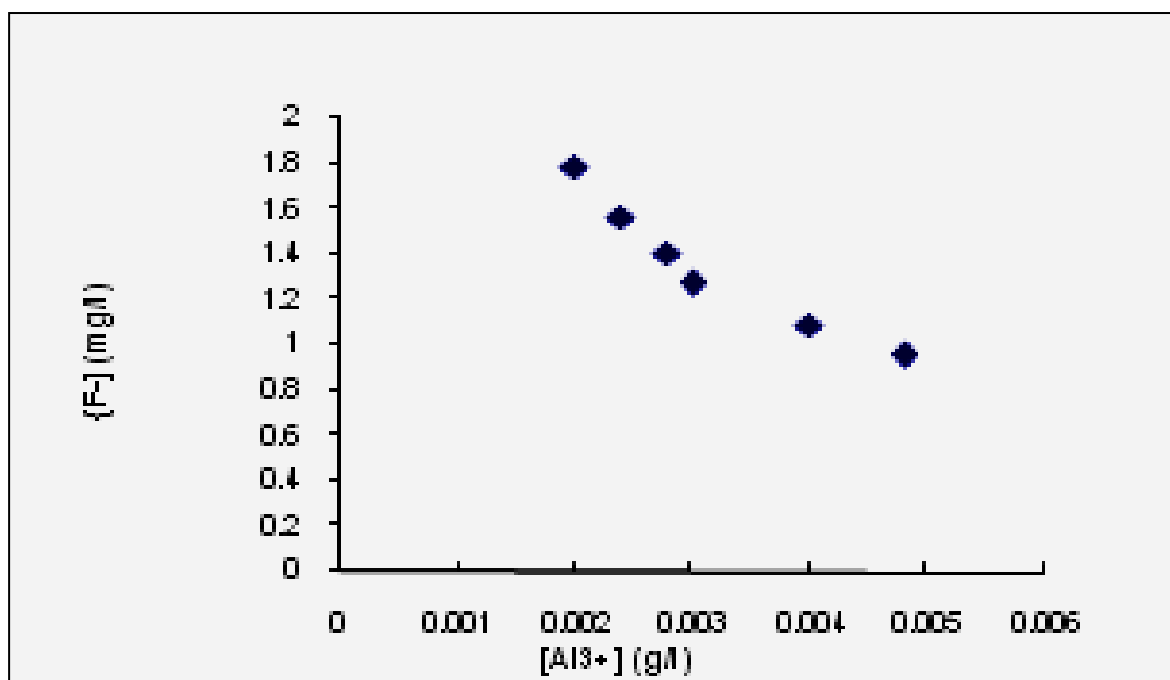


Figure 2. Variation of residual fluoride against added aluminium concentration.

2. 4. 2. Effect of pH

Based on adsorption of fluoride ion on Al(OH)₃ which is related to the pH of the studied water according to the equilibrium (1).

We repeat the same steps of the previous experiment as mentioned in (2.4.1) by fixing the temperature and the added optimal concentration of aluminium sulfate but changing the pH by buffer solutions. The results are presented in Table 4 and Figure 3.

Table 4. Relation between the pH and the residual fluoride [Al³⁺] = 0.0024 g/l, T = 27.6 °C.

pH	4.02	5.07	6.00	7.02	8.00
[F ⁻] (mg/l)	1.80	1.46	1.23	1.27	1.50

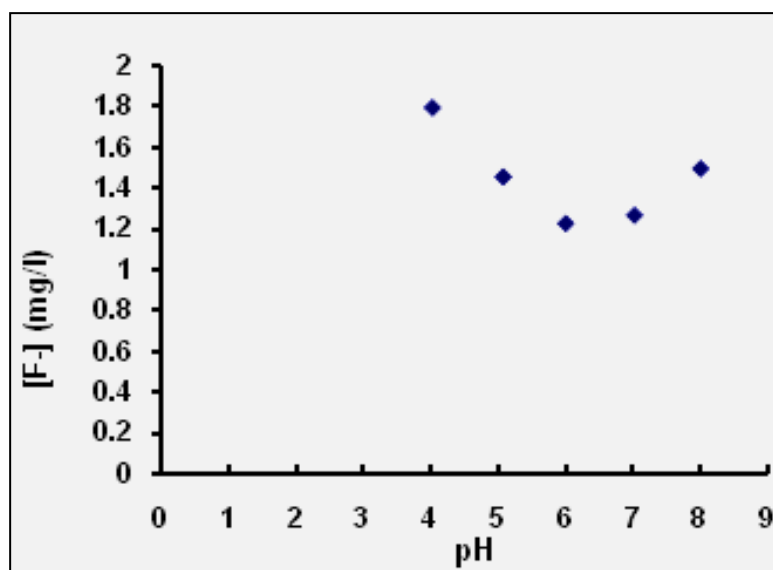


Figure 3. Variation of residual fluoride against pH.

2. 4. 3. Effect of temperature T

The same steps of the experiment are repeated as mentioned in (2.4.1) by fixing the added optimal concentration of $\text{Al}_2(\text{SO}_4)_3$ and the optimal pH, but changing the temperature.

The results were presented in Table 5 and Figure 4 [5].

Table 5. Relation between the temperature and the residual fluoride $[\text{Al}^{3+}] = 0.0024 \text{ g/l}$, $\text{pH} = 8$.

T (°C)	20.0	26.5	30.0	40.0	45.0
[F ⁻] (mg/l)	1.67	1.50	1.41	1.21	1.10

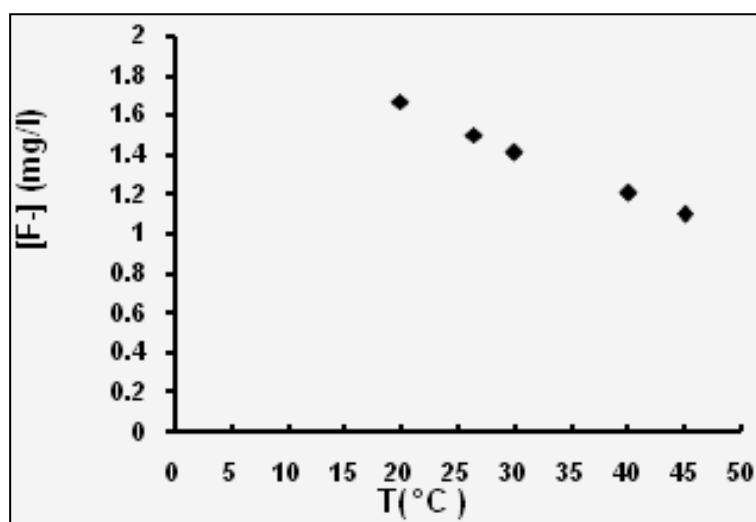
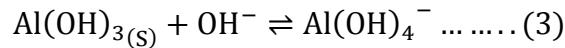
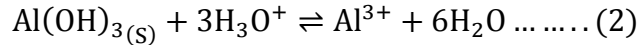
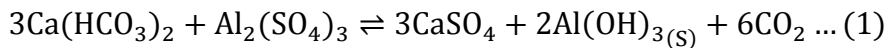


Figure 4. Variation of residual fluoride against temperature.

3. EQUATION AND EQUILIBRIUM



$$\eta = Ae^{B/T} \dots \dots (1)$$

$$V = \frac{Z \cdot D \cdot E}{4\pi\eta} \dots \dots (2)$$

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Where: η = viscosity coefficient ;
 (A , B) = constants related to the quality of the liquid;
 T = temperature of solution;
 D = dielectric constant of water;
 Z = Zeta potential.
 E = electric field intensity;
 V_{mob} = speed of observed Particles:
 V = speed of Particles in an electric field .

4. RESULTS AND DISCUSSION

- ✓ According to the results of Table 2 we observe that the high concentrations of (Ca^{2+} , Mg^{2+} , SO_4^{2-} , Cl^-) exceed the WHO standards of water. This related to the geological characteristics and the structure of rocks.
- ✓ The results of Table 3 indicate that the concentrations of residual fluoride are decreased when the values of added aluminium concentration are increased. This can be explained by the formation of gelatinous aluminum hydroxide (equilibrium1) which adsorbs F^- [5]. The optimal concentration of aluminium is 0.0024 g/l.
- ✓ The results of table (4) show that:
 - In acidic medium: The residual F^- is decreased when the pH is increased which is proved by equilibrium (2).
 - In basic medium: The residual F^- is increased when the pH is increased which is proved by equilibrium (3).
 The optimal chosen pH = 7.6 leads to a residual fluoride concentration equals 1.5 mg/l which fits the OMS standard.
- ✓ According to the results of Table 5 we observe that residual $[\text{F}^-]$ is decreased when T is increased, this can be proved by the following:
 Increasing T leads to the decrease of [equation of Guzman-andrad] (1), so V is increased [equation (2)]. As a result V_{mob} is increased [equation (3)].

V_{mob} increases the probability of convergence F^- from $\text{Al}(\text{OH})_3$ particles which augment the adsorption of F^- on the surface of the particles [6, 7]. The optimal chosen $T = 26.5\text{ }^\circ\text{C}$ leads to a residual fluoride concentration equals 1.5 mg/l which fits the OMS standard.

5. CONCLUSION

- According to the quantity of fluoride in the water of Oasis region of Algeria ,it appear that most of them Contain surplus exceeds the standard value of (WHO)⁽⁹⁾ with a total high hardness.
- The present investigation indicates that reducing fluoride from water is economic method because using a small amount of $\text{Al}_2(\text{SO}_4)_3$ is needed for this purpose.
- Through the study of factors affecting (concentration, pH, temperature) it is possible to choose the best conditions for a reduction process with $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$ by adding an amount at a concentration of 0.030 g / l, pH = 7.6 and a temperature of 26.5 °C.

ABRIVIATIONS

EDTA⁽¹⁾: ComplexonIII (Ethylene diamine tetra acetic acid disodium salt).

MO⁽²⁾: methyl orange

Ph.Ph⁽³⁾: phenolphthalein

TA⁽⁴⁾: alkalimetric title.

TAC⁽⁵⁾: The complete alkalimetric title.

TISAB⁽⁶⁾: total ionic strength adjustment buffer

WHO⁽⁷⁾: World Health Organization.

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References

- [1] WHO, *Fluoride in drinking water*, IWA Publishing, London, 2006.
- [2] *Programme National de Santé Bucco-Dentaire en Milieu Scolaire*, Ministère de la Santé et de la Population, Algérie, Mai 2001.
- [3] *Circulaire interministérielle du 07 Mai 2001 relative au Programme National de Santé Bucco-Dentaire en Milieu Scolaire*, Ministère de la Santé et de la Population, Ministère de l'Education Nationale, Algérie.
- [4] Jean Rodier et coll., *L'analyse de l'eau: eaux naturelles, eaux résiduaires, eau de mer*, 8^e édition; Paris 2005, pp. 219-221 and 299-310.

- [5] Achour, Youcef, Leïla Samia, *Defluoruration des eaux souterraines du sud algérienne par la chaux et le sulfate d'aluminium*, Université Mohamed Khider – Biskra, Algérie, 2001.
- [6] Yaping Zhao, Xiuyan Li, Lu Liu, Fuhua Chen, *Carbohydrate Polymers* 72(1) (2008) 144-150.
- [7] M. G. Sujana, G. Soma, N. Vasumathi, S. Anand, *Journal of Fluorine Chemistry* 130(8) (2009) 749-754.