

# Evaluation of Fluoride Concentration in Water Treatment Plants of Baghdad City

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**Abstract:** Fluoride is one of the elements in water that humans need at a certain rate, but it poses a health hazard if its concentration in drinking water is more than the body requirement. In order to analyze the fluoride concentration in drinking water in Baghdad city and estimate its expected effects on consumers, data were taken monthly throughout three years (2012-2014) for raw and supply water. The results show that the fluoride concentration in Tigris river was below 1.5 ppm and it was found that AL-Wahda and AL-Rasheed W.T.P.s have the highest percentage of removal for fluoride. Using artificial neural network found that its concentration was affected by temperature, pH, total solids and suspended solid where the pH and suspended solid were the most influential on fluoride.

**Keywords:** Evaluation, Fluoride, Baghdad, Artificial Neural Network (ANN)

## 1. Introduction

At present, the nature of potable water is a major task due to the expansion of pollution in water bodies. Fluoride is one of the pollutants that undermine the forms of life, especially people [1]. Fluoride is the natural component in water samples. The sources of fluoride in drinking water are the geological and artificial sources, but the main source is the geological source [2]. The major source of fluoride in groundwater is geological formation. The sources of fluoride in water are industrial wastewater from the coal plants, phosphate industries, ceramic and glass production, aluminum industries, and many other processes like fertilizer manufacturing, electroplating, rubber, uranium refinement, semiconductor manufacturing etc. also through air, water, food, medicine and cosmetics [3,4]. More than 99% of fluoride in the human body is stored in ivory, enamel and bone. The concentration of fluoride in tissues is mainly based on fluoride intake, exposure duration and interrelated factors like growth rate, tissue growth stage and surface area [5]. WHO guidelines indicate that the ideal level of fluoride concentration is 1 and 1.2 ppm for warm and cold climate respectively. This variance is due to increased water consumption in the warm climate [2]. For drinking water, the maximum concentration of fluoride is 1.5 ppm [2,6]. The concentration of fluoride in drinking water of less than 1.5 ppm is beneficial for the production of teeth and the development of bone structure, preventing tooth decay while excessive consumption of fluoride above 1.5 ppm causes tooth decay chronic skeletal poisoning, bone softening and collapsed vertebrae, and neurological damage in severe cases. There is no cure for fluorosis resulting from excessive consumption of fluoride and is considered a fatal disease [7,8]. Many methods have been attempted to get rid of fluorides from water which are nanofiltration and ultrafiltration, adsorption, electrophoresis, precipitation, ion exchange and reverse osmosis [1,6,9,10]. The aim of this research is to compare between the concentration of fluoride in raw water of Tigris River and supply water from several water treatment plants in Baghdad city, thus quantifying the efficiency of these W.T.P.s, and estimate the effect of temperature, pH, total solids and suspended solid on fluoride concentration.

## 2. Study Area

Eight water treatment plants were selected in the city of Baghdad. They are start from Al- Karkh W.T.P. in northern Baghdad to Al-Rasheed W.T.P. south of Baghdad. Figure (1) explains the location of water treatment plants along the Tigris River and the pollution sources effecting on them.

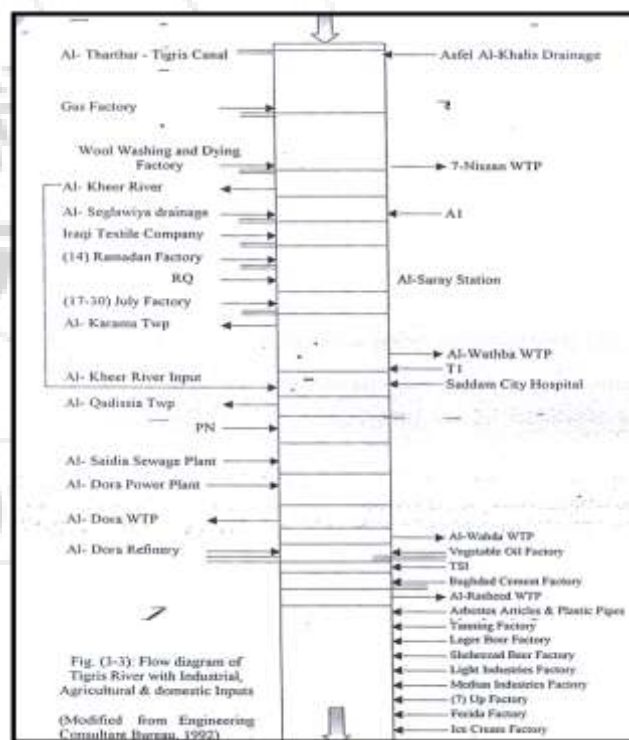


Figure 1: The location of W.T.P.s along the Tigris River and sources effecting on them. [11]

## 3. Fluoride Removal from Water (Defluoridation)

Fluoride removal methods can generally be divided into three categories according to the main removal mechanism:

- **Chemical additive method:** chemicals used include the addition of lime alone or with aluminum or magnesium salts with coagulation aid this method called Nalgonda

technique [12]. Where the calculated amounts of lime, alum and bleaching powder are mixing with water, then this water is processed with flocculation, sedimentation, filtration and disinfection. The whole process takes about 2-3 hours for about 200 people in batches [6].

- **Contact precipitation:** is a technology where phosphate and calcium compounds are added to the water to remove fluoride from it [12].
- **Adsorption:** This method is done by passing the raw water through a bed containing materials that removes fluoride. The materials that have been successfully used are activated alumina, Fly ash, bone char and clays [12].
- **Ion exchange method:** synthetic chemicals, which are represented by anion and cation exchange resins were used for defluoridation. Some of these resins are Deacedit FF (IP), Polyanion (NCL), Amberlite IRA 400, Tul-sion A - 27, Amberlite XE - 75 and Lewatit MIH - 59 [13].

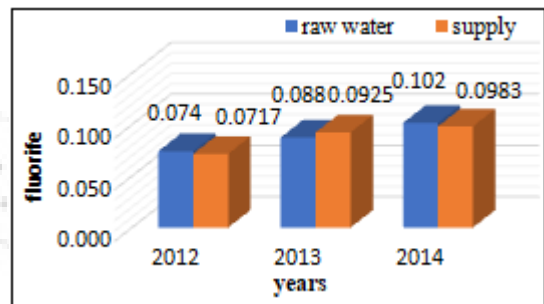
#### 4. Data Collection and Analysis

In this research, monthly data were collected for three years (2012-2014) for the concentration of fluoride, suspended solids and total solids as well as temperature and pH for the same period of time. This information was taken from raw water at the points located before the treatment plants located in the city of Baghdad on the Tigris River and also took the same samples of water from those stations. Water treatment plants included in the study were Al-Karkh, SharqDijla (7- Nissan), Al-Karama, Al-Wathba, Al-Qadissia, Al-Dora, Al Wahda and Al-Rasheed. Microsoft Office Excel 2016 and IPM SPSS 23 software were used for data analysis. Schemes were performed using Microsoft Office Excel 2016, while the multilayer prediction artificial neural network analysis was performed by IPM SPSS 23 software.

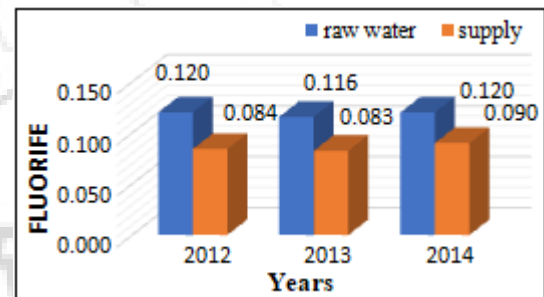
#### 5. Results and Discussion

Fluoride values were compared in the raw water and supply water from each water treatment plant as average annual value as shown in Figure (2). It was found that the fluoride concentration decreased significantly after the exit of the water from the water treatment plants except Al Karkh WTP., where the concentration of fluoride increased by a small percentage in 2013 and this may be due to an operational defect in this WTP. and such a defect occurred in the water treatment plants of AlQadissia and Al Dora in the year 2012. In Figure (3), fluoride removal rates were found in all the water treatment plants studied. It was found that the water treatment plants of Al Wahda and Al Rasheed have the highest percentage of removal. It is worth mentioning that the concentration of fluoride in the Tigris River is less than the concentration allowed by the World Health Organization, but the purpose of the above procedures to make sure that the method of water treatment used in Baghdad in particular and in Iraq in general does not cause any health hazard on the consumer. Table (1) shows the months containing the maximum and minimum values of fluoride in the raw waters of the Tigris River, where the raw water sampling points were at the front of the water treatment plant and therefore these points were referred to

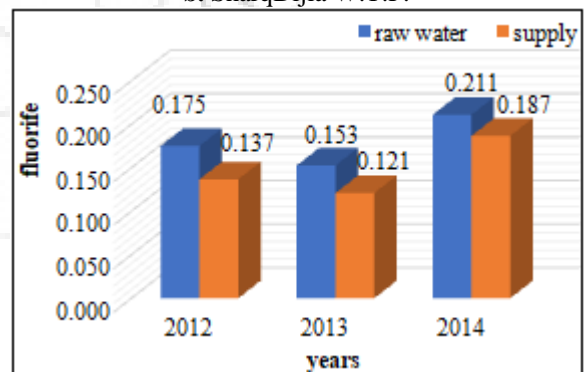
by the name of the treatment plant. It was clearly that the concentration of fluoride increases in winter and decreases in the summer. This was a clear indicator of temperature effects on fluoride concentration. Table (2) illustrates that the total solids and suspended solid have a direct effect on fluoride and that the fluoride concentration relationship with them is a direct relationship. A high coefficient of determination between the observed and predicted value was obtained by using the artificial neural network as shown in Figure (4) where the value of  $R^2$  reached to 0.845 when the fluoride was a dependent variable and the temperature, pH, total solids and suspended solid were non-dependent variables. Table (3) shows the effect of the four variables on the concentration of fluoride where the pH and suspended solid were the most influential.



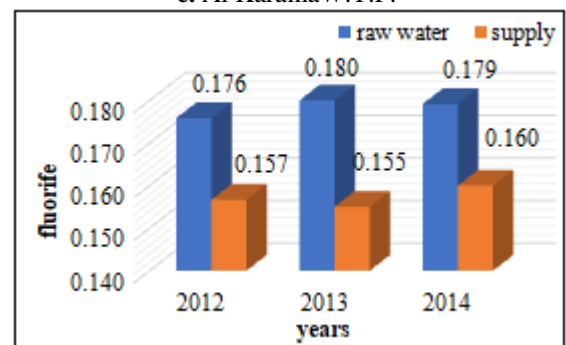
a. Al Karkh W.T.P.



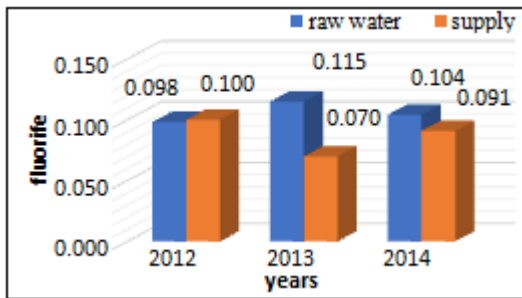
b. SharqDijla W.T.P.



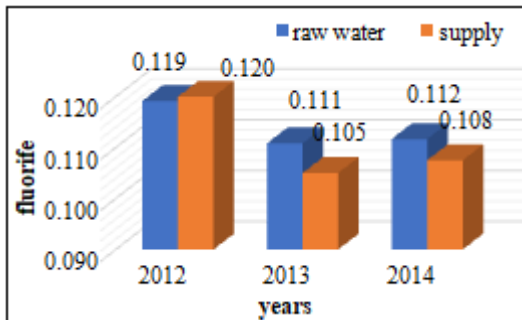
c. Al Karama W.T.P.



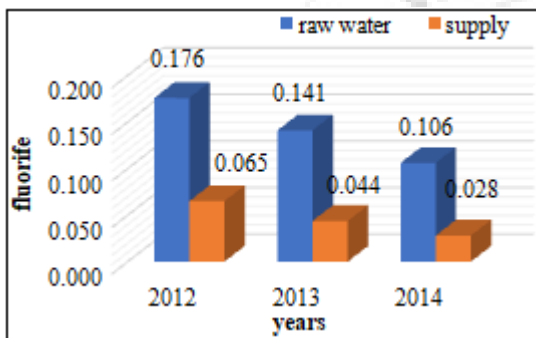
d. Al Wathba W.T.P.



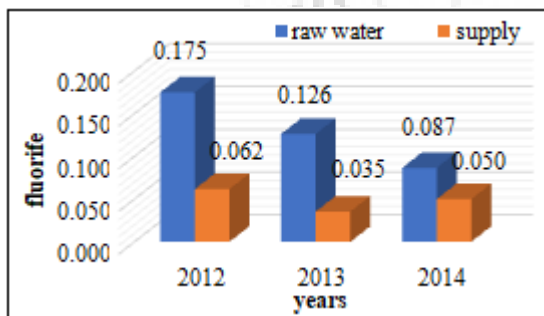
e. Al Qadissia W.T.P.



f. Al Dora W.T.P.



g. Al Rasheed W.T.P.



h. Al Wahda W.T.P.

Figure 2: Concentration of fluoride in raw water and water from supply of each water treatment plant

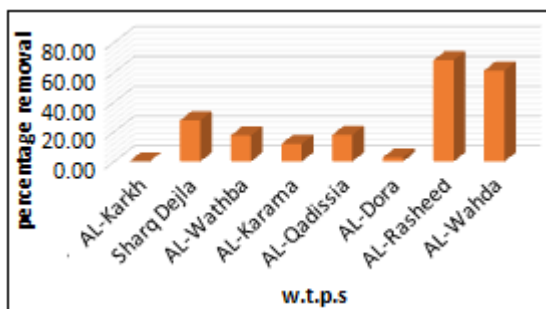


Figure 3: Fluoride percentage removal

Table 1: The maximum and minimum values of fluoride for raw water before treatment plants in Baghdad

W.T.P.	Max Value	Month	Min Value	Month
AL-Karkh	0.117	October	0.07	January
SharqDejlja	0.13	May	0.11	January
AL-Wathba	0.213	November	0.157	March
AL-Karama	0.21	August	0.17	May
AL-Qadissia	0.16	July	0.08	September
AL-Dora	0.17	January	0.09	July
AL-Rasheed	0.19	Jun	0.12	October
AL-Wahda	0.17	January	0.09	July

Table 2: The maximum and minimum values of fluoride, temperature, pH, total solids and suspended solid

parameters	Max Value	Month	Min Value	Month
Fluoride as F	0.15	January	0.125	September
Temperature	29	August	14.08	January
pH	7.974	June	7.879	October
Total solids	716.125	November	525.042	May
Suspended solid	400.375	February	47.708	September

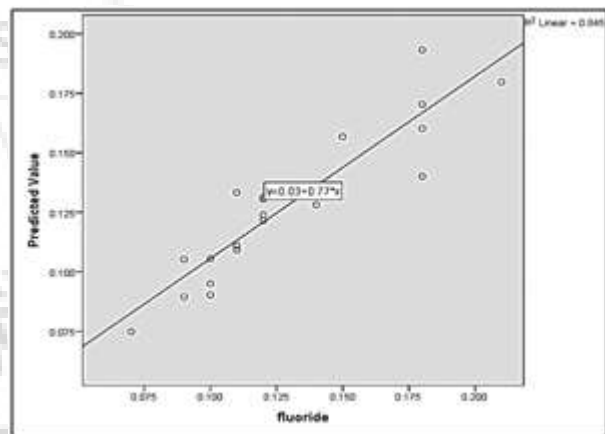


Figure 4: Observed and predicted chart for fluoride

Table 3: The importance of the independent variables

variables	Importance	Normalized Importance
TS	0.126	30.1%
SS	0.231	55.3%
Temperature	0.225	53.9%
pH	0.418	100.0%

## 6. Conclusion

- 1) The fluoride level in raw and supply water was below the permissible limit of WHO (1.5 mg F/L).
- 2) There is an inverse relationship between fluoride in raw water and temperature where the highest level of fluoride was during winter specifically in January was 0.15 mg F/L corresponding with the lowest temperature (14.08°C in January) and its level decreased slightly to reach its lowest value in summer (0.1252 mgF/L) in September.
- 3) pH and suspended solid were the most influence variables on fluoride concentration.
- 4) From multilayer prediction by artificial neural network (ANN) found that  $R^2$  value reached to 0.845.
- 5) The conventional method that used for raw water treatment was efficient in fluoride removal from water in all water treatment plants as it does not cause any danger on human health.

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## Author Profile



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