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**RESEARCH ARTICLE**

# Performance Evaluation of Al- Karkh Water Treatment Plant in the City of Baghdad

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## *Abstract*

In this study, one of the physical characteristics of the supplied water as represented by water turbidity was used as a tool to assess the performance of Al-Karkh water treatment plant in Baghdad. The Laboratory data collected from the Mayoralty of Baghdad for the period from January 2000 to December 2002 were used in this study. Statistical Analysis techniques were used to evaluate the performance of the plant in terms of the removal of turbidity with normal, 2-day, and 30-day moving averages. The study revealed that the raw water quality is fluctuated in many seasons as a result of flush water periods. Also, it shows that on the basis of water turbidity data, the 1-day average, the performance of water treatment plant was found to be well above (98%) according to the Iraqi drinking water standards. For 30-day moving average, the study shows that the quality of the potable water of Al-Karkh water treatment plant was (68%) violated the Unites State Environmental Protection Agency (USEPA) standards, while (99%)of the samples were compliance with that standards according to 2-days moving average. Adding and advanced water treatment units is worth to be considered and operating water treatment plant according to the scientific conventional methods with a Systematic maintenance for the different stages of water treatment plant is highly recommended.



## 1. Introduction

One of the most important natural resource in the world is Water, and life cannot exist and most industries could not operate without water. Therefore, providing safe and reliable source of water is thus an essential prerequisite for the establishment of a stable community [16]. It is also an important tool for economic development and plays an effective role in social prosperity [6, 14].

Around the world and in many countries, some of potable water have become contaminated [5] and that is due to the growing of population, which increased the economic activities and industrialization and that led to create an increased demand for fresh water in addition to the severe misuse of natural resources[15]. As a result of that, the quality of surface waters have got a great awareness around the world and therefore, many researchers have studied to evaluate the performance of the water treatment plants [5, 2, 3] and on how to improve the quality of drinking water[7,11,13,1].

The quality of water is described by four categories: physical parameters which include color, turbidity, temperature, and, in particular, taste and odor. The second is the chemical parameter where is chemical characteristics of waters are sometimes evidenced by their observed reactions, such as the comparative performance of hard and soft waters in laundering. The third parameter is biological where is microbiological agents are very important in their relation

to public health and may also be significant in modifying the physical and chemical characteristics of water. Finally radiological parameter Radiological factors must be considered in areas where there is a possibility that the water may have come in contact with radioactive substances [10, 9].

Turbidity is one of these physical characteristics, it is the presence of suspended material such as (clay) of range of 0.004 mm (clay) to 1.0 mm (sand), finely divided organic material, plankton, and other particulate material in water or it is a measure of the clarity, or transparency, of the water[10,17].The unit of measure is a Nephelometric Turbidity Unit (NTU) which is determined by reference to a chemical mixture that produces a reproducible refraction of light [9]. World Health Organization (WHO) has set the guideline value for the residual turbidity in drinking water at 5 (NTU) [12] which is the same value for Iraq drinking water standards. Clay or other inert suspended particles in and of themselves may not adversely affect health, but water containing such particles may require treatment to make it suitable for disinfection. Therefore turbidity reduces disinfection efficiency by consuming the disinfectant and shielding the microorganisms [10].

The aim of this work is to evaluate the performance of Al-Karkh water treatment plant and how it is compliance with national and international guidelines.

## 2. Materials and Methods:

### 2.1- Al-Karkh water treatment plant.

In 1924, Baghdad water supply committee was established and in 1955 many projects were constructed such as Al-shalichiya, Al-sarafiya, Al-karada and Al-masbah .In 1962, the plants were extended and the capacity of supplying Baghdad city with drinking water reached to 300MLD.

Al- Karkh water treatment plant is located in Tarmiya, 30 km in the north of Baghdad, on the West Bank of the Tigris River and has (1km²) total area. The reason for this location is to prevent the effect of Tharthar-Tigris channel and from the effect of salts on human and industrial impurities, which are discharged directly to the river. Al-Karkh water treatment plant supplies the city of Baghdad with about 55.8% of its demand of drinking water for both Karkh and Rassafa sides.

The first stage of the project consisted of two identical streams that were constructed in 1986, while the second stage consists of one stream constructed in 1988. The total capacity of the plant now is (1365) Million liter/day or (455) Million liter/day per stream.

Al-Karkh low lift pump station comprises 14 pumps with different capacities ranging from (55-228) million liter/day. Each stream in Al-Karkh water treatment plant consist of eight pre-settling tanks each tanks have a dimension of 40m*12m*8m(L*W*D) and a capacity of 57 MLD per tank to treat high water turbidity levels up to 15000 NTU.

In addition, each stream contains sedimentation tanks (clariflocculators) with a 51m in diameter, with a circular flocculation compartment having a 15m in diameter and 4 paddle wheels. Then the water flow into the filtration stage where each stream consists of 20 rapid gravity filters, each filter have a 15m*13m in area and the depth of gravel layer is 7cm and sand layer is 90cm. Al-Karkh plant has a full chemical treatment and three storage tanks. Two of these tanks have the dimensions of (110m*103m*4.5m) and the third tank has a dimensions of (209m*103m*4.5m), each tank is divided into two parts and each part is again divided into two parts .In the first part division the chlorine is injected.

In the high lift pump station, there are 8 pumps which can discharge 300million gallon per day, each one has a capacity equals to 282MLD. The pressure is between 68-76m and with a power equal to2300kW.

### 2.2- Sampling and Data Analysis

Samples that used in this study were collected for three years by the staff who working in the water treatment plant that are part of the mayoralty of Baghdad. Samples were taken daily from the river (close to the intake) to represent the raw water samples and from the tap to represent the supplied water. These samples were measured instantaneously after collection with many other parameters in addition to the turbidity. Statistical approaches, like ANOVA, T-Test, and correlation test for all the factors during the studied period and for the 6 stations, were done by analyzing the data using SPSS and statistica.

## 3. Results and Discussion

### 3.1- Al-Karkh Raw Water

Figure (1) shows a time plot of daily turbidity observations at the intake of Al-Karkh W.T.P. for a three-year period. It is interesting to note the wide variation in the level of turbidity throughout this period. Outliners or freak points

are well defined in this time plot. The high turbidity observations occur in two periods; the November- December and the March-April period. Due to this phenomenon, the use of pre-settling tanks found to be warranted.

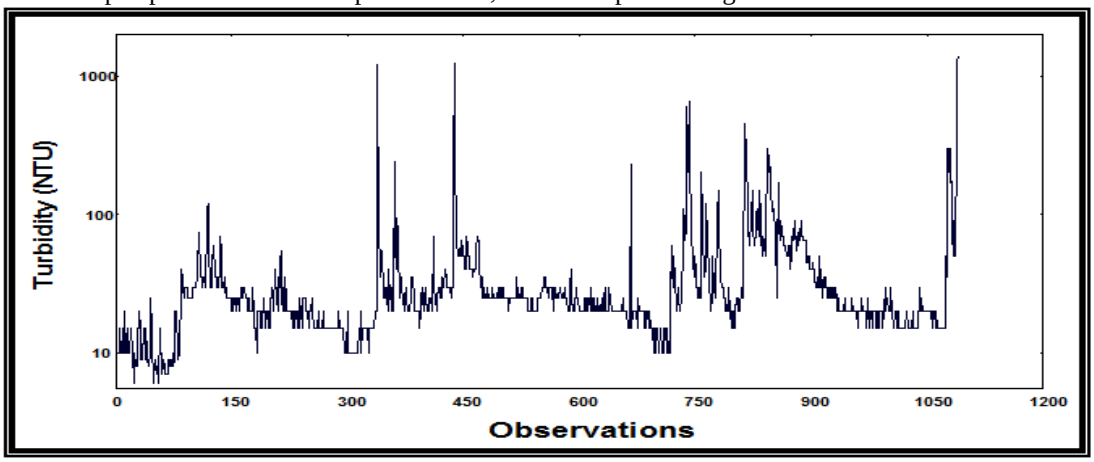


**Figure (1), Daily Turbidity Observation at the Intake of Al-Karkh W.T.P.**

Table (1) shows the statistics of the daily observations of turbidity at Al-Karkh water treatment plant within the city of Baghdad. A wide range of turbidity level is observed which spanned from 6 NTU to 1400 NTU. The mean of the observations was about 39.858 NTU with a standard deviation of 98.118 and that lead to 2.23% as a coefficient of variance. This shows that there was a wide variation in turbidity levels. This is clear from the value of (CV) for the water treatment plant and indicates that there were flushing periods during rainy seasons which is confirmed the study achieved by [4], while in summer the turbidity is low and organic in nature.

**Table (1), Statistical Description of Daily Raw Water Turbidity for Al-Karkh WTP**

| W.T.P | N | Max. | Min. | Mean | Std. | Variance | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|
| Al-Karkh | 1090 | 1400 | 6 | 39.858 | 89.118 | 7942.065 | 10.805 | 140.169 | 2.23% |

### 3.2- Analysis of Al-Karkh Water Supplied by its Water Treatment Plant

Figure (2) shows a time plot of daily water turbidity data for Al-Karkh water treatment plant (W.T.P) that covered a three – year period. This period started in 1/1/2000 and ended in 31/12/2002.It is interesting to note that the turbidity line graph of this figure mimics that of the raw water turbidity for the same plant. Periods with adverse water turbidity readings coincide with each other's in both figures.

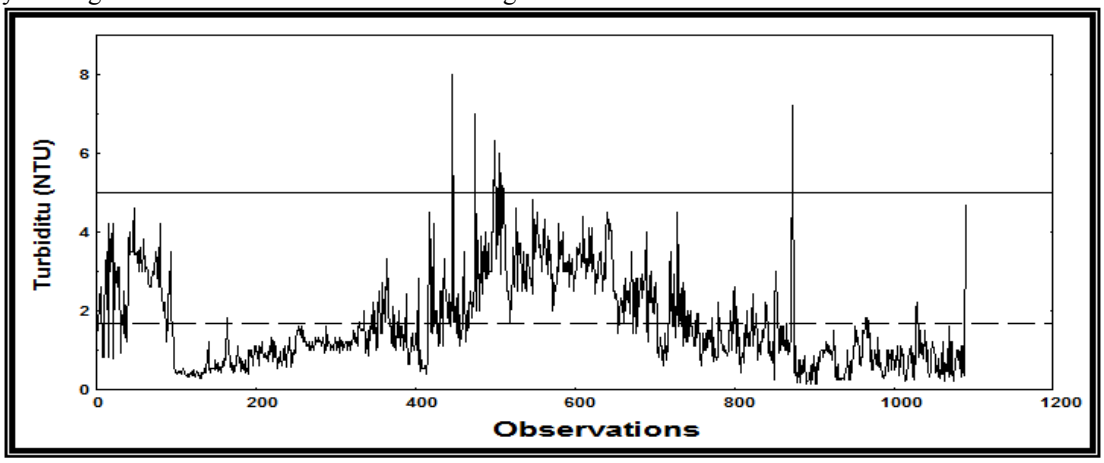


**Figure (2), Daily Turbidity Supply Water of Al-Karkh W.T.P.**

It can be seen from figures. (3) and (4) which show the histogram and the cumulative frequency graph for the supplied water turbidity data that on the average, there is about 98% compliance with the Iraqi drinking water standards, which calls for 5 NTU. It is interesting to note that the time of violation of this standard limits is in November-December and March-April. It is well known that November-December is the period of rainy season,

while March-April is the period of high river flow resulting from snow melting up in the Tigris catchment. Both periods contribute to turbidity.

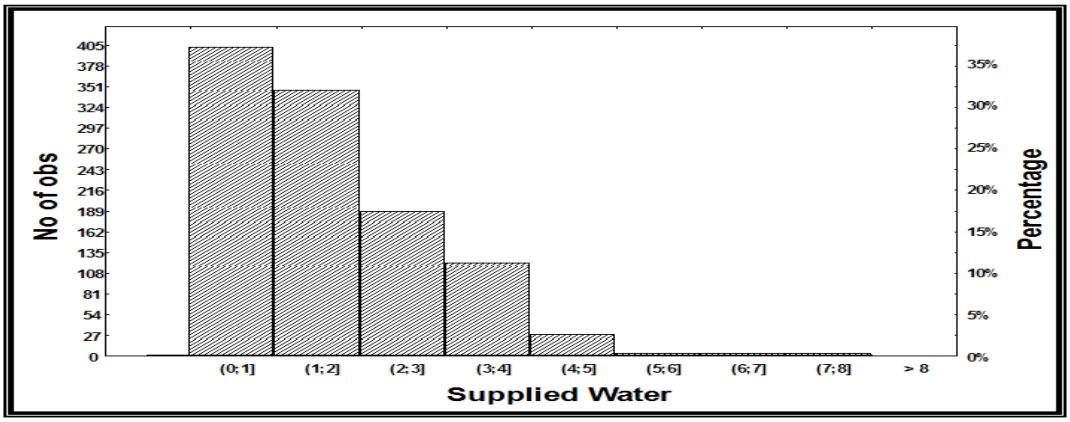


**Figure (3), Frequency of Supplied Water Turbidity of Al-Karkh W.T.P.**

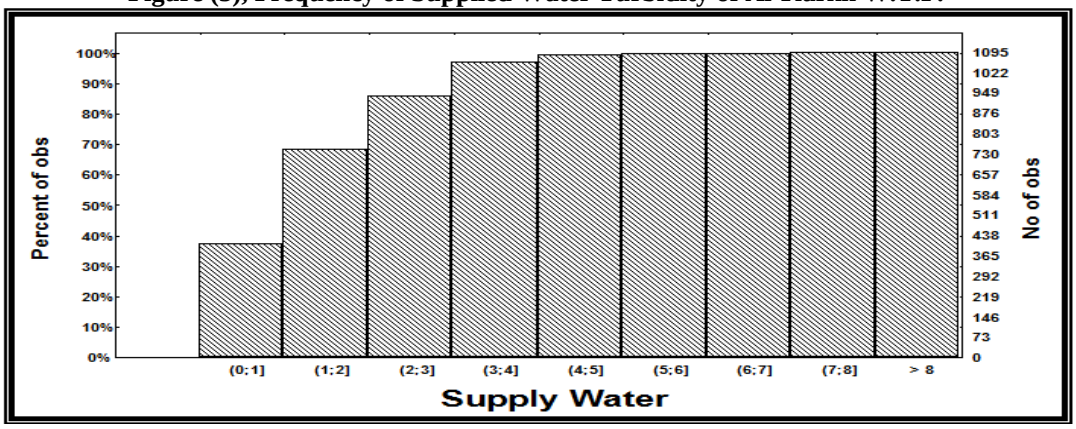


**Figure (4), Cumulative Frequency of Supplied Water Turbidity of Al-Karkh W.T.P.**

Table (2) lists the statistical description of the daily turbidity data of the supplied water as produced by Al-Karkh WTP. It can be seen that mean value of the turbidity level of the supplied water was about 1.7 NTU during the past 3- year period, with a standard deviation of 1.15 NTU, resulting in coefficient of variation (CV) of 68.5%. This value is somewhat high as confirmed by the range, which is found to be 0.12 to 8 NTU.

**Table (2), Statistical Description of Daily Turbidity Supplies Water of Al-Karkh WTP**

| W.T.P | N | Max. | Min. | Mean | Std. | Variance | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|
| **Al-Karkh** | 1090 | 8 | 0.12 | 1.679 | 1.151 | 1.324 | 1.102 | 1.381 | 68.5% |

According to the American standards on drinking water quality, which calls for monthly (30-day) average of 1 NTU, it can be seen from figures. (5) and (6) that compliance with this standard limit is not more than 32%. This meant that on the average about 68% of the days of the year, or 248 days this standard limit is violated.

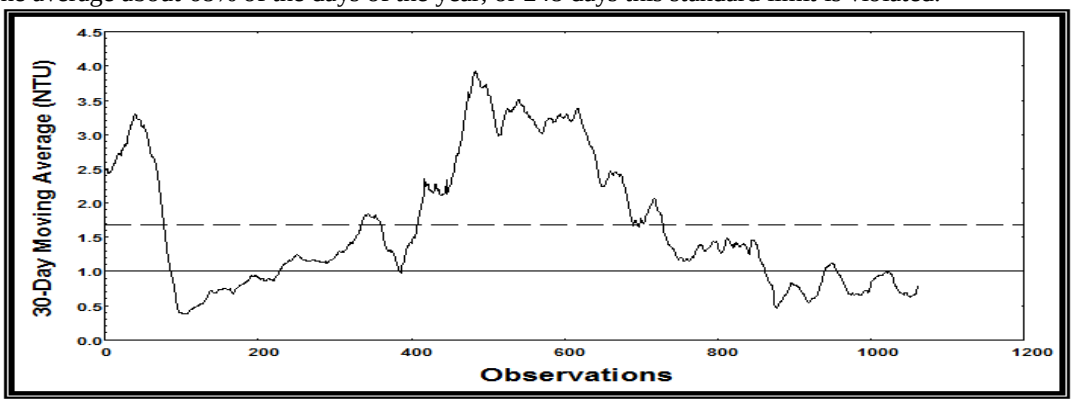


**Figure (5), 30 - day Moving Average of Turbidity Water Supplied from Al-Karkh W.T.P**

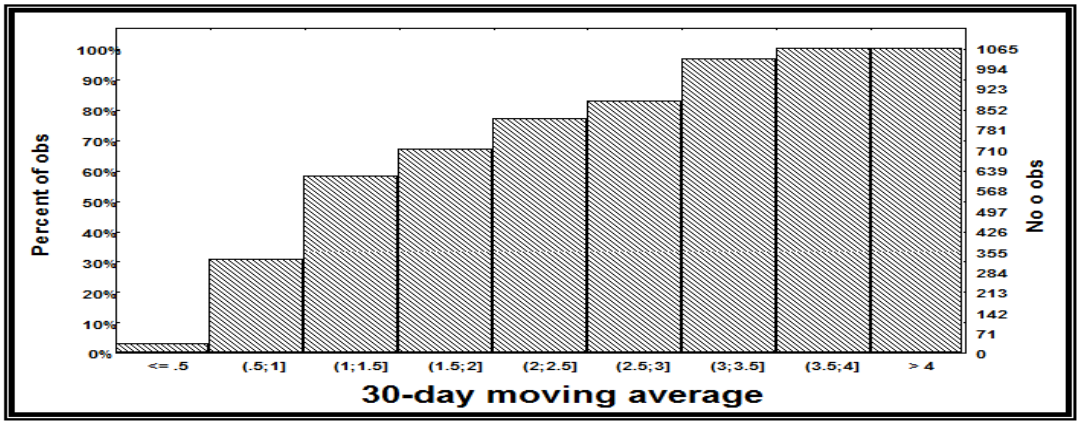


**Figure (6), Cumulative Frequency of Turbidity Water Supplied for Al-Karkh W.T.P**

Table (3), which gives the statistical description of 30-day average of the turbidity data of the supplied water for the city of Baghdad for Al-Karkh water treatment plant. From this table, it can be seen that the annual average value of the turbidity of the supplied water as pumped from Al-Karkh W.T.P. is about 1.68 NTU with a standard deviation of about 0.955 NTU. This gives a coefficient of variation is 56.8%. This is somewhat high as confirmed by the range value, which is 0.38 to 3.39 NTU.

**Table (3), Statistical Description of 30-Day Moving Average of Turbidity Supplies Water for Al-Karkh Water Treatment Plant**

| W.T.P | N | Max. | Min. | Mean | Std. | Variance | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|
| **Al-Karkh** | 1061 | 3.9316 | 0.383 | 1.681 | 0.955 | 0.912 | 0.664 | -0.870 | 56.8% |

Referring to figures (7) and (8), which shows a time plot and a cumulative frequency curve for the two-day average turbidity readings for Al-Karkh W.T.P. The American EPA standard limits on drinking water calls for a maximum of 2-day average of 5NTU. Based on this standard, then it can be stated that there is a 99% compliance with this standard as far as turbidity quality is concerned. This means that there is, on the average, about 4 days in any year that this standard is violated.

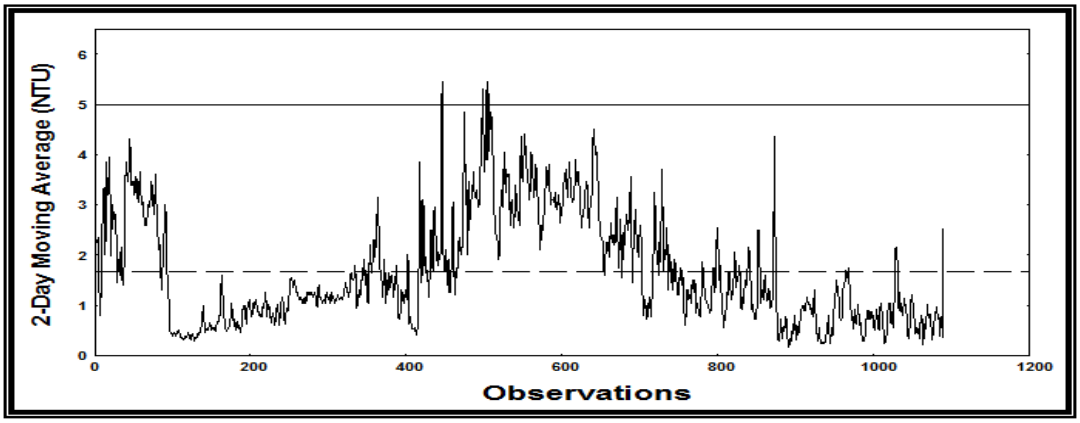


**Figure (7), Two- day Moving Average of Supplied Water Turbidity Data of Al-Karkh W.T.P**

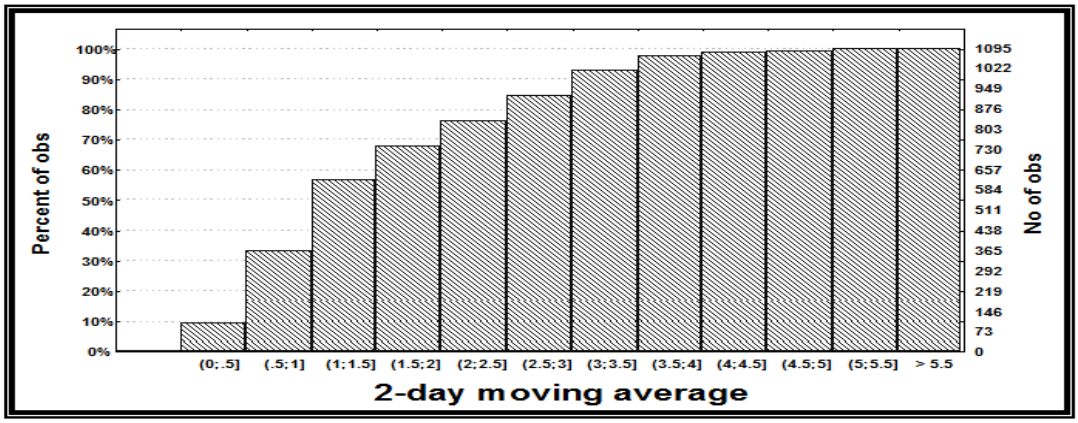


**Figure (8), Cumulative Frequency of 2–day Moving Average of Turbidity Supply Water of Al-Karkh W.T.P.**

Table (4), which listed the statistics for a 2-day turbidity average for Al-Karkh water treatment plant. The mean of 2-day average is found to be 1.678 NTU for Al-Karkh W.T.P. That means that a compliance with the 2-day average turbidity level as set by the EPA. The coefficient of variation for 2-day average statistic is about 64.7%; with a range value of 0.18 to 5.45 NTU and this is rather good according to this standard.

**Table (4), Statistical Description of 2-day Moving Average for Turbidity Supply Water**

| W.T.P | N | Max. | Min. | Mean | Std. | Variance | Skewness | Kurtosis | CV |
|---|---|---|---|---|---|---|---|---|---|
| **Al-Karkh** | 1089 | 5.45 | 0.175 | 1.678 | 1.089 | 1.188 | 0.846 | -0.111 | 64.7% |

### 3.3- Removal and the Correlation between Raw and Supplied Water Turbidity

Table (5) shows the removal efficiency of water turbidity, compliance or violation with the Iraqi, and the World Health Organization standards. In addition a comparison of the mean value of turbidity removal data is carried out with the American standards as issued by Environmental Protection Agency (EPA).the values show some compliance with other studies that is close to the mentioned water treatment plant in terms of the raw water quality and treatment process and that give relatively similar results[8].

**Table (5), Removal Efficiency and Compliance or Violation with the Standards for Al-Karkh Water Treatment Plant**

| Plant | Removal Efficiency (%) | Iraqi & WHO standard (5) NTU | USEPA 30-day standard (1) NTU | USEPA 2-day standard (5) NTU |
|---|---|---|---|---|
| **AL-Karkh** | 95.78 | C (98%) | V (68%) | C (99%) |

C (98%) denotes that compliance is 98% with Iraqi and WHO standard
V (68%) denotes that violated is 68% with USEPA standard

Correlation and regression analyses were carried out on water turbidity data in an attempt to correlate raw water data with that of the supplied water but to no avail .The reason for this is thought to be due to the fact that supplied water turbidity sampling is not synchronized so as to account for a lag time. The lag time here is, of course, equals to the actual detention time of the whole water treatment plant. Table (6) shows this vividly as reflected by the low correlation coefficient ((R-adjusted =zero).

**Table (6), Supply-Raw Relationship of Al-Karkh Water Treatment Plant**

| Plant | Equation | R square | Adjusted R square |
|---|---|---|---|
| **Al-Karkh** | 1.694 – 3.51*10-4 * Raw | 0.001 | 0.000 |

## 4. Conclusions

1- Turbidity data for the Tigris River shows that it ranged from 6 to 1400 (NTU), this indicated the need for using the pre- settling tanks especially when the turbidity is relatively high.
2- For 1-day average, turbidity data of supplied water show that Al-Karkh water treatment plant was (2%) violated with the Iraqi and world health organization standards.
3- For 30- day average, turbidity data of supplied water show that Al-Karkh water treatment plant in this study was (32%) compliance with the (USEPA).
4- For 2-day average, turbidity data of supplied water show that Al-Karkh was (99%) compliance with the United State environmental Protection Agency (USEPA) standard.
5- No significant statistical relationship between the raw and supplied (potable) water using turbidity data at Al-Karkh water treatment plant.

## 5. Acknowledgements

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