REDUCTION OF ORGANIC POLLUTANTS FROM WATER TREATMENT PLANTS USING WASTES OF ALUM INDUSTRY

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ABSTRACT

Various organic compounds increase in surface water due to the agricultural drains located, the industrial effluents of industrial activities, fish farming cages and random domestic drainage. First, a survey analysis was carried out for five different water treatment plants (WTPs) in Greater Cairo. Coagulation, flocculation and sedimentation were carried as a technique for the removal of total organic carbon (TOC) concentration. Coagulation has been carried out using alum dose between 27-32 g/m^3 with average removal percent of (TOC) (16% - 41%), In this study, De-Aluminated Kaolin (DAK)-a waste by-product from alum production-in various dosages between 0.5g - 4 g were added and an average removal percent of (TOC) (45.7% - 77.1%) at contact time of 15 minutes has been found to achieve the maximum (TOC) removal at concentrations of (TOC) (6.6 mg/l) and pH equal 8.3.

Keywords: Organic matter**;** alum**;** Water Treatment Plants**;** Total organic carbon (TOC)**;** De-Aluminated Kaolin (DAK).

INTRODUCTION

There is a growing concern about wide spread contamination of surface with various organic compounds due to the agricultural drainage water, industrial effluents and domestic sewage which all contain highest concentration of Total organic carbon (TOC)(Abdelhalim *et al.,* 2014).

There are many methods suggested for the removal of organic compounds from aqueous solutions. These methods have been classified in two principal categories: destructive processes such as destructive oxidation with ozone, hydrogen peroxide, or manganese oxide and recuperative processes such as adsorption into porous solids, membrane separation, ion exchange and solvent extraction (Uddin *et al.,* 2007).

The reduction of the organic content in raw water by different methods including: activated carbon (Symons *et al.*, 1981) and oxidation (using either ozone or chlorine dioxide as the oxidant), for the degradation of the organic matter to reduce the trihalomethanes THMs formation potential of the raw water (Glaze *et al*., 1987 and George *et al.,* 2008).

De-aluminated kaolin (DAK) is a waste by-product of aluminum extraction from kaolin by sulfuric acid. (DAK) can be obtained after acid leaching process of kaolin, the acid-leaching process gave a yield of 47.35 ± 1.64% of alum using raw kaolin (Mostafa *et. al,* 2001), the remaining kaolin is called de-aluminated kaolin is used as adsorbent material for ammonia (Mawla *et al*., 2016).

In this study de-aluminated kaolin (DAK) which used as adsorbent material for the removal of total organic carbon (TOC), the addition of (DAK) will be applied before the pre-chlorination in order to reduce the organic load in the source water to avoid the formation of carcinogenic disinfection by-products (DBPs)**.**

MATERIALS AND METHODS

1 Survey analysis for TOC: A survey study was carried out to determine the concentrations of (TOC) in raw and treated waters from five WTPs in Greater Cairo revealed the most polluted sites. Analysis was done according to (APHA, 2012).

The selected WTPs were (El-Tebben, El-Fustat, Mostorod, Embaba, and Gezeret El-Dahab) the total quantity produced as drinking water by these WTPs in sum is about 3,700,000 m3/day.

Total organic carbon (TOC) were analyzed with a (TOC) analyzer (Sievers-5310) method adopted from APHA 5310 C and optimized for the laboratory conditions.

2 Treatment process description: The treatment process in the five mentioned WTPs is almost the same in sequence and techniques. It began by mechanical screening for blocking large objects, followed by primary disinfection for inactivation of pathogens by using chlorine gas, and then the optimum dose of aluminum sulfate coagulant is added to remove particulates and reduce the organic load, than, the water is subjected to rapid sand filters to remove the rest of the turbidity. In final step post-disinfection is applied to assure residual chlorine in the produced water that protects it against any further pollution in the distribution networks.

3 Reduction of (TOC): In this section of the study, the effect of de-aluminated kaolin (DAK) adsorbent material for (TOC) was studied by applying various conditions that affect the adsorption of organic matter in raw water.

3.1. De-Aluminated kaolin (DAK): DAK is a by-product from alum production from Aluminum Sulfate Company of Egypt in Abu zaable Qalyubiyah. (DAK) was obtained after acid leaching process of kaolin, the acid-leached process yields of aluminum sulfate using calcined kaolin, the remaining residue is called de-aluminated kaolin (DAK) were grinded into the following particle sizes (0.08, 0.125, 0.2, 0.315, 0.4 and 0.63 mm diameters) to be used in this study as adsorbent material for (TOC).

3.2. Treatment methodology: Treatment procedures carried out by the following steps:

- Samples of raw water from River Nile by different concentration of (TOC).
- Dosages of 3g DAK were added to examine the (TOC) treatment efficiency.
- The stirrer was adjusted for 15 rpm and let to stand for about 10 minutes.
- The samples were then filtered through a syringe 0.22 micro filter.
- The remaining (TOC) was then measured using (TOC) analyzer (Sievers-5310).

The removal efficiency is then calculated by the following equation (1

$$\text{Total (TOC) removal efficiency \%} = \frac{(C_{\circ} - C)}{C_{\circ}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $C_{\circ}$ = Total (TOC) without the action of adsorbent (mg/l)

C = Total (TOC) after using the adsorbent (mg/l)

3.2.1. Effect of particle size: Experiments were carried out on samples to determine the effect of particle size on the adsorption process. Varying particle sizes (0.08, 0.125, 0.2, 0.315, 0.4 and 0.63 mm diameters of (DAK)) were used 1000 ml of sample of 6.6 mg/l concentrations of (TOC) was poured in 1000 ml BEAKER with 3 g de-aluminated kaolin (DAK) and stirred at 15 rpm for 15 minutes. The samples were then filtered through a syringe 0.22 micro filter.

3.2.2. Effect of de-aluminated kaolin (DAK) dosage: Experiments were carried out on samples to determine the effect of adsorbent dosage on the adsorption process. Various dosages were added (0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4 g). 1000 ml of sample of 6.6 mg/l concentrations of (TOC) was poured in 1000 ml BEAKER and stirred at 15 rpm for 15 minutes, pH of the sample was equal 8.3.

3.2.3. Effect of Total organic carbon (TOC) concentration (adsorbate): Various (TOC) concentrations were prepared (3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 8, 8.5, 9 and 11 mg/L) by applying U.S. EPA method 9060A through dissolving (0.2128 g) of potassium hydrogen phthalate in 100 ml deionized water (DI) to prepare 1,000 mg/L of (TOC) stock solution (U.S.EPA, 2006).

Then the mentioned solutions were prepared through dilution from the (TOC) stock solution which poured in 1000 ml BEAKER with 3 g (DAK) and stirred at 15 rpm for 15 minutes. The initial pH of the sample was equal 8.3 in the natural operation range.

3.2.4. Effect of pH on (TOC) adsorption capacity: To determine the effect of pH on the adsorption process; 100 ml synthetic samples in Erlenmeyer flask were adjusted with 1M H_2SO_4 or 1M NaOH to pH (2, 4, 6, 6.5, 7, 7.5, 8, 8.5, 10 and 12). The pH effect on adsorbent 3g DAK activities was determined at constant (TOC) load (6.6 mg/L) and mixing speed of 15 rpm for 15 minutes.

3.2.5. Effect of time: The effect of contact time on removal of (TOC) was studied with various adsorbents at initial concentrations of (TOC) (6.6 mg/l) in time ranging (5, 15, 25, 35, 45, 55, 65, 70 and 75 minutes) and mixing speed of 15 rpm on adsorbent 3g DAK in 100 ml samples in nine Erlenmeyer flasks.

2.4 Removal efficiencies of (TOC): The samples were analyzed for (TOC) and the removal efficiencies were determined through equation (1).

RESULTS AND DISCUSSIONS

1 Survey analysis for TOC and THMs: As mentioned in section 2.1 a survey study carried out to determine the WTPs site having high (TOC) values and the data are presented in Figure (1).

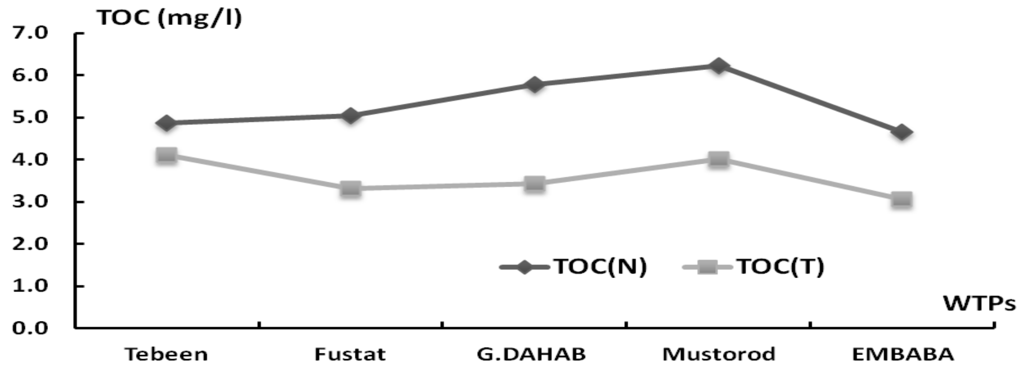

Fig. (1): Concentration of TOC (mg/l) in Greater Cairo WTPs raw water River Nile (N) - Drinking Water tap (T).

In the Egyptian regulation (TOC) has no standard limit, but (TOC) a good indicator for organic pollution. In Figure (1), the amount of organic matter TOC is maximum at Mostorod WTP with 6.63 mg/l; the presence of many companies such as (Al Delta steel, petroleum pipelines, Cairo Petroleum) The treatment plants (WTPs) was coagulation has been carried out using alum dose between 27-32 g/m^3 with average removal percent of (TOC) (16% -41%)

2 Removal of (TOC) using (DAK):

2.1 Effect (DAK) particle size on (TOC) removal:

Batches experiments were carried out for removal of (TOC) from water sample. The effects of (DAK) particle size are shown in figure (2).

Decreasing the (DAK) particle size greatly increases the (TOC) removal to reach maximum (68.2 %) and a particle size of 0.08 mm. This could be attributed to the surface area which increases with decreasing the (DAK) particle **size (Buragohain *et. al.*, 2013).**

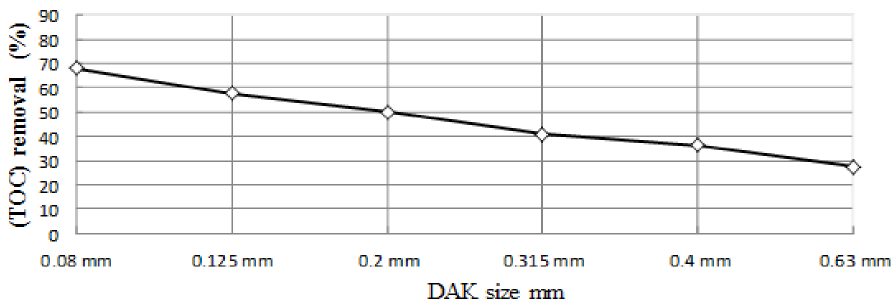

Fig. (2): Effect particle size of (DAK) in (TOC) removal percentage**.**

3.2.2 Dose Effect of (DAK): Batches experiments were achieved to determine the optimum (DAK) dose that will achieve the best (TOC) removal percentage. Dose the effects of (DAK) are in figure (3).

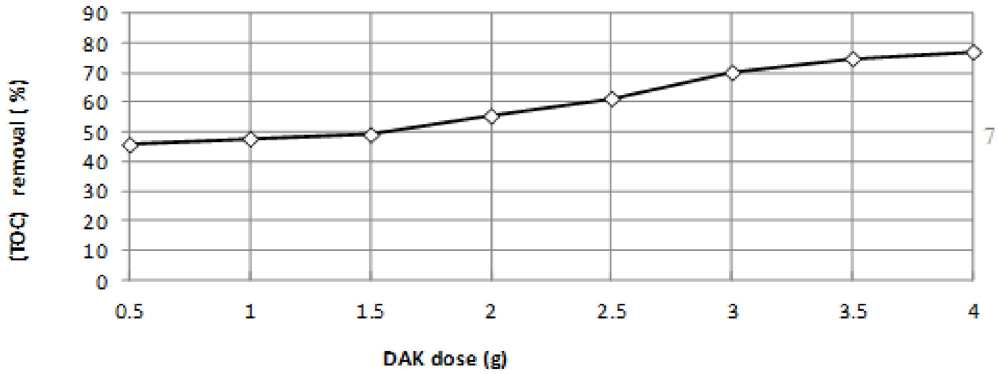

Fig. (3): Dose effect of (DAK) in (TOC) removal percentage

Increasing dose of (DAK) increases (TOC) removal percent until it reach maximum (77.1%) using (DAK) dose of 4g. Increase the number of active sites by increasing (DAK) dose.

3.2.3 Effect of (TOC) concentration on the treatment by (DAK): The effects of the initial sample concentration on removal of (TOC) with DAK were experimented according to synthetic sample.

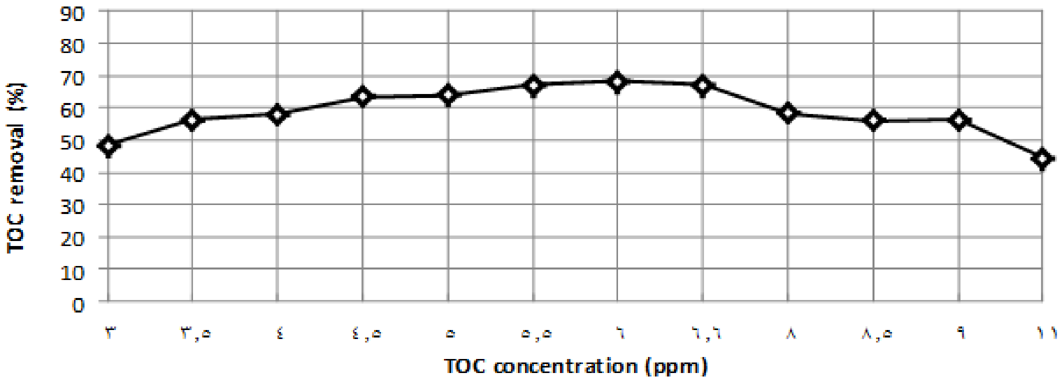

Fig. (4): Effect of initial concentration on TOC removal % by using (DAK)

Figure (4) displayed that high initial concentration of (TOC) increased the (TOC) removal percent until it reached maximum 68.2% with 3 gm (DAK). This could be attributed to adsorption process is dependent on initial concentration of adsorbent which infer that the used mass of (DAK) has been saturated with the organic matter.

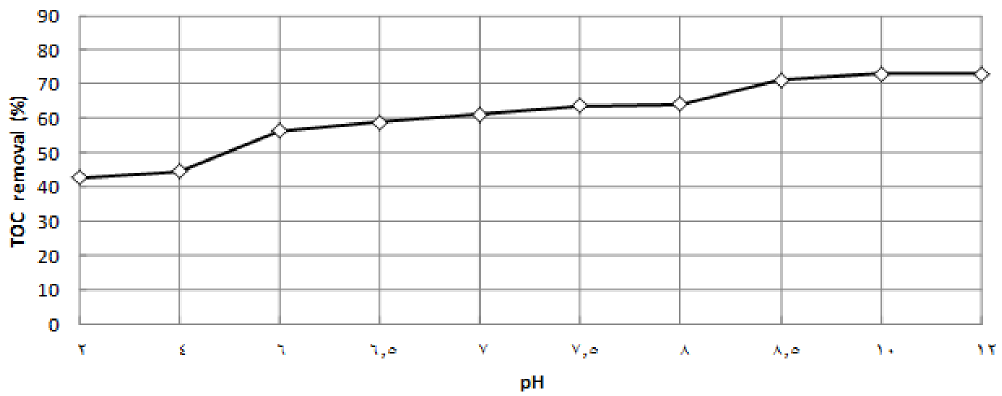

Fig. (5): Hydrogen ion concentration Effect on (TOC) removal % by DAK.

3.2.4 Effect of pH in (TOC) removal by DAK: Results presented in figure (5), showed that the removal efficiency of (TOC) by DAK depended on pH values which affects on the surface charge of the adsorbent, degree of ionization, and speciation of adsorbate species. Increasing pH from 2 to 12 increases the (TOC) removal percent. (TOC) the removal 73% is much favorable in alkaline condition of NaOH caused DAK surface area increases (Phair e*t al.* 2014) and micro-cracks on the particles of DAK due to strong base NaOH concentration and be fragile (Sukmak *et al.* 2014).

3.2.5 Effect of contact time in (TOC) removal by DAK.

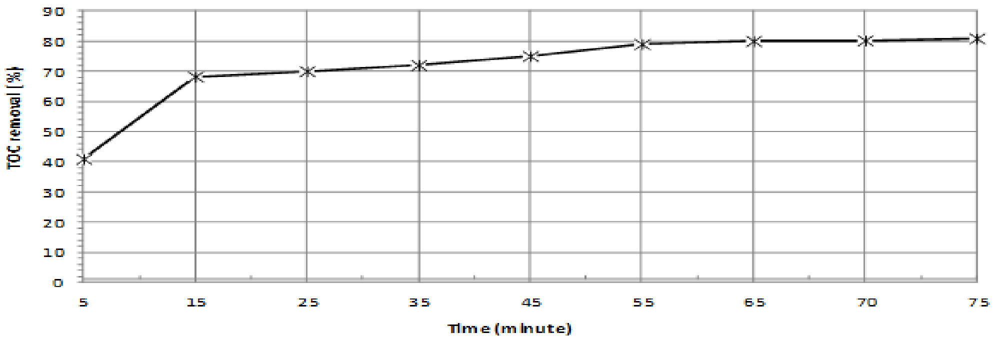

Fig. (6): Contact time Effect on (TOC) removal % by DAK.

The above results show removal process can be considered very fast because of largest amount of (TOC) attached on surface area DAK within the first 15 min of experiment (68.2% removal of (TOC)). The equilibrium time required for the adsorption of (TOC) on DAK is almost 45 min (55.1%). Low significant change in (TOC) removal was observed after 55 min. It was seen from the experimental results that the percentage removal increases with increasing of contact time till equilibrium is occur.

CONCLUSION

The survey on Cairo water treatment plants revealed that Mostorod-WTP is the most polluted spot by organic matter with TOC concentration of 6.63 mg/l for the raw water, with economical and environmental significance DAK a by-product from alum production from Aluminum sulfate company which using de-aluminated kaolin in water treatment show that DAK removed up to 60 % removal of (TOC) using 3 g of DAK 0.08 mm. Recommendation in study the Effect of pH in (TOC) removal by DAK which add NaOH to sample the (TOC) removal 73**%** is much favorable in alkaline condition of NaOH caused DAK surface area increases so we can used the modified DKA.

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خفض الملوثات العضوية من محطات تنقية المياه باستخدام مخلفات صناعة الشبه

[١]

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المستخلص

تتزايد المركبات العضوية المختلفة في المياه السطحية بسبب المصارف الزراعية الموجودة والنفايات السائلة الصناعية الناتجة من الأنشطة الصناعية وأقفاص تربية الأسماك والصرف المنزلي العشوائي. تم عمل مسح ميدانى أولى لخمس محطات لتنقية مياه الشرب بالقاهرة الكبرى، حيث مراحل الترويب والتنديف والترسيب كطريقة لإزالة تركيز الكربون العضوى الكلي باستخدام مرحلة الترويب بجرعة شبه ما بين ٢٧–٣٢ جم / م ٣ وكان متوسط نسبة إزالة للكربون العضوى الكلي (١٦%– ٤١%)، في هذه

الدراسة تم استخدام الكاولين منزوع الألومنيوم جزئياّ (كأحد المخلفات الثانوية لعملية إنتاج الشبه) بجرعات مختلفه حيث تمت إضافة جرعات تتراوح من ٠,٥ جم إلى ٤ جم مع الحصول على متوسط نسبة إزالة للكربون العضوى الكلي (٤٥,٧%– ٧٧,١%) في وقت التلامس ١٥ دقيقة للوصول إلى أقصى إزالة للكربون العضوى الكلي عند جرعة كربون عضوى كلى٦,٦ مجم/ ل وأس هيدروجينى ٨,٣.

الكلمات المفتاحية: المواد العضوية؛ الشبه؛ محطات تنقية المياه؛ الكربون العضوي الكلى؛ الكاولين منزوع الألومنيوم جزئياّ