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# Evaluating efficiency of $H_2O_2$ on removal of organic matter from drinking water

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ABSTRACT

$H_2O_2$ has been widely used because of intensified pollution of water resources like rivers, lakes, and dams to organic matters and formation of carcinogenic disinfection by-products (DBPs). This study aimed at evaluating the rate of organic matter removal from drinking water by $H_2O_2$. Water samples were taken from Gharasoo River and effluent of wastewater treatment plant in Farabi hospital. Samples containing humus organic matters (A, B, C, and D) as well as pesticides including Diazinon and 2,4-dichlorophenoxy-acetic acid (2,4-D) were also prepared. Measurements were performed using a spectrophotometer at a wavelength of 253.7 nm. COD decreased as the concentration of $H_2O_2$ increased in all the samples and maximum removal was observed at the concentration of 10 mg/l of $H_2O_2$. In the samples containing humus, COD removal rates were also increased by increasing hydrogen peroxide doses with the highest removal rates of 81, 70.9, 65.21, and 62.85% observed for humus A, B, C, and D, respectively. The lowest absorption rate occurred at neutral pH and high correlation coefficient (i.e. $R^2 = 0.92$) which was observed between COD removal and absorption rates of organic matter for all the samples. According to the results, it can be concluded that $H_2O_2$ is an appropriate oxidant for the removal of organic matter from drinking water. On the other hand, COD due to these materials can be estimated through measuring their absorption rates.

*Keywords:* Organic matter; $H_2O_2$; Water treatment; Drinking water

## 1. Introduction

Due to the severe pollution of water sources, including rivers, lakes, and dams in recent decades that mostly happened through increased entry of domestic, industrial, and agricultural sewage, concentration of organic base water pollutants is growing at an alarming manner [1]. Natural water may contain micro-organisms and dissolved or suspended organic and inorganic compounds that may be introduced from natural sources or leachates of waste deposits.

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Municipal and industrial wastes may increase a wide range of organic and inorganic impurities in water. Inorganic compounds of water originate from the erosion of rocks, soils, and sediments [2]; and organic compounds in natural waters result from the decomposition of plant and animal materials. The most common natural organic matters in surface water are humic acids, Folovic and Himatomelanic, algae and other micro-organisms [3–5]. Synthetic organic compounds may reach surface waters through urban and industrial wastewater discharges and urban and agricultural runoff. Concentration of organic matter may vary from zero (in protected groundwater) to 10–30 mg/l in contaminated surface water and rich in organic matter [5]. Main categories of problematic synthetic organic compounds causing health concerns are surfactants, pesticides and herbicides, detergents, solvents, polychlorinated biphenyls, and disinfection byproducts (e.g. Trihalomethanes [THMs]) [6–8]. These compounds at adequate concentrations influence quality and usage of natural water resources [2]. Although organic materials are harmless, they are important due to their ability to react with chlorine and production of disinfection by-products (DBPs), which are mostly carcinogenic in nature [9]. THMs are by-products of the reaction of chlorine with natural organic matter. Although concentrations of halomethane compounds produced in disinfected drinking water is low, but they are very important due to their toxicity, long-term and continuous exposure, and the population at risk [10]. In 1975 these compositions were identified as class A human carcinogen by United States Environmental Protection Agency [11,12]. Hydrogen peroxide and air removal system, air stripping, and activated carbon can be used to remove variety of organic compounds, such as THMs, odor, color, and other toxic organic compounds [13–16]. Hydrogen peroxide is a strong oxidizing agent and a volatile chemical matter [17], which decomposes into oxygen and water. This decomposition is faster in the base environment than the acidic one [18]. The use of hydrogen peroxide as an oxidizing and disinfectant agent was common in the early nineteenth century and before Pasteur's famous theory about bacteria and the infectious diseases [19,20]. It is also applicable to the existing water treatment plant and with the least changes in the treatment process; it can be used to increase the oxidizing agent prior to rapid mixing unit. In 1950, the production of pure hydrogen peroxide with stabilized formulation was provided using an electrochemical process. To measure the concentration of organic matter both specific and non-specific standard is used [5,7]. Non-specific measures are COD, TOC, BOD5, TOD, ThOD, color, UV absorption, and Fluorescence. In the specific method, gas chromatography, mass spectroscopy, and high performance liquid chromatography are used [2]. In this research removal of organic matter in terms of COD and the rate and extent of UV absorption by organic matter was studied and COD removal rates were regressed against absorption rate of organic matter. The main purpose of the present work was to determine the efficiency of hydrogen peroxide in the removal of natural organic matter, 2-4-D, and diazinon pesticides.

## 2. Material and methods

In a cross-sectional study, water samples were taken from Gharesoo River and effluent of wastewater treatment plant of Farabi hospital. Some samples containing humus organic matters, as well as Diazinon and 2-4-D were also prepared. To obtain the optimum pH for the removal of organic substances, 2-4-D pesticide stock solution of 1000 mg was prepared and then 5 mg/l of 2-4-D was added to each of the six systems. The pH of the samples was set at 4, 5, 6, 7, 8, and 9 using 0.1 N hydrochloric acid. Then, 5 mL of commercial hydrogen peroxide solution was added to each sample set. The samples underwent rapid mixing at 380 rpm for one minute prior to be kept in static conditions for 30 min. After completion of organic materials' oxidation process, 50 mL was taken from the top layer of the sample for further testing. To determine optimal concentration of hydrogen peroxide, a volume of 1–6 ml of the hydrogen peroxide solution was added to each container, respectively, and mixed for 1 min. After 30 min, 50 ml was taken from the surface of the samples. The absorbance of samples was determined at 253.7 nm by Varian spectrophotometer UV-120-02. The tests were also performed for samples containing diazinon and 2-4-D humus-bearing samples A, B, C, D, and the samples taken from wastewater outlet of Farabi Hospital. Humus samples were prepared from liquified plants. All sampling and testing were done based on the standard method, the twentieth edition [21]. The correlations between COD removal rate and extent of adsorption were obtained by Excel software.

## 3. Results and discussion

Results are presented in Table 1 and in Figs. 1–8. The results indicate that the rate of COD removal in samples of Gharasoo river water increase with increasing hydrogen peroxide level and the maximum rate of removal (75%) occurred at the concentration of 10 mg/l of hydrogen peroxide in downstream Gharasoo. COD removal rates were also increased by the increasing amount of hydrogen peroxide in the samples containing humus with the highest removal rates of 81, 70.9, 65.21, and 62.85% observed for Humus A, B, C, and D, respectively. Similarly, studies of Amin et al. [22], Stefan et al. [23], Chu [24], Ghaly et al. [25], Daneshvar et al. [26] reported that the removal of organic matter is increased by increasing $H_2O_2$ level. Hydrogen peroxide as a scavenger for hydroxyl radicals undergoes folowing reactions [27,28]:

$$OH^\circ + H_2O_2 \rightarrow HO_2^\circ + H_2O \quad (1)$$

$$2OH_2^\circ \rightarrow H_2O_2 + O_2^\circ \quad (2)$$

$$OH^\circ + OH^\circ \rightarrow H_2O_2 \quad (3)$$

Since the radicals reaction of $H_2O_2$ is less than OH; when enough hydrogen peroxide is present in the solution, there is a competition between organic materials to react with an OH radical [29].

COD rate and the extent of organic matter adsorption, after the addition of different amounts of hydrogen peroxide for different types of humus samples, are given in Fig. 4.

The effect of different pH on the adsorption of 2-4-D was determined in the present study and the lowest absorption rate (with a fixed amount of hydrogen peroxide added) occurred at neutral pH (pH: 7) (Fig. 5) which was used as a measure for the removal of organic matter by hydrogen peroxide.

Adsorption of organic matter samples decreased with increasing hydrogen peroxide level and for all the samples tested (i.e. water samples containing 2-4-D, diazinon, humus, A, B, C, D, output sample of Farabi hospitals, and river-water of Gharasoo)

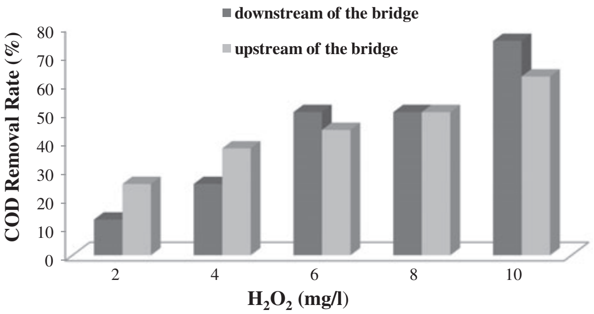

Fig. 1. COD removal rates of Gharasoo River in upstream and downstream of the bridge of the city by adding various amounts of $H_2O_2$.

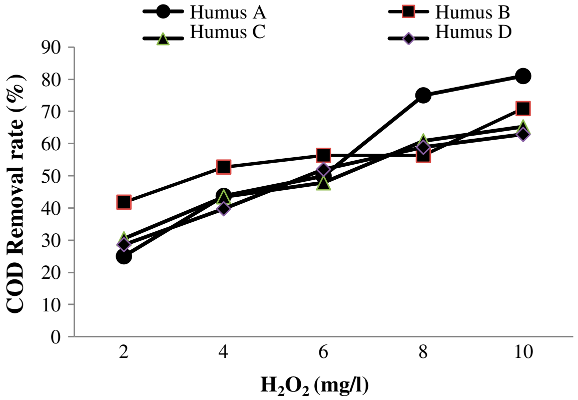

Fig. 2. COD removal rates in samples containing humus by adding different amounts of $H_2O_2$.

Table 1
Removal COD of the samples before and after the increase in $H_2O_2$

| Sample | COD (mg/l) before an increasing of hydrogen peroxide COD (mg/l) | COD (mg/l) after an increase in hydrogen peroxide (mg/l) | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 4 | 6 | 8 | 10 |
| a* | 32 | 28 | 24 | 16 | 16 | 8 |
| b* | 64 | 48 | 40 | 36 | 32 | 24 |
| Humus A | 32 | 24 | 18 | 16 | 8 | 6.08 |
| Humus B | 55 | 32 | 26 | 24 | 24 | 16 |
| Humus C | 46 | 32 | 26 | 24 | 18 | 16 |
| Humus D | 70 | 47.97 | 42.18 | 33.6 | 28.79 | 26 |
| C* | 62 | 50 | 32 | 28 | 26 | 24 |
| 2–4-D** | 50 | 45.89 | 42 | 31.9 | 18.48 | 7.89 |
| Diaznon** | 68 | 56 | 53.6 | 29.32 | 21.82 | 15.2 |

*a: Ghara Sou River, downstream of the bridge.

*b: Ghara Sou River, upstream of the bridge.

*C: Output of Farabi Hospital Wastewater.

**Each 2-4-D and diazinon pesticides used is 5 mg/l.

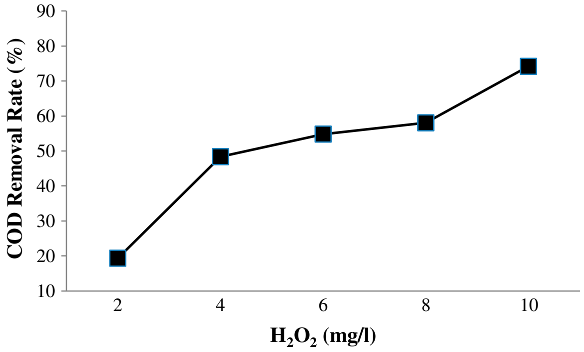

Fig. 3. COD removal in wastewater outlet samples of Farabi Hospital.

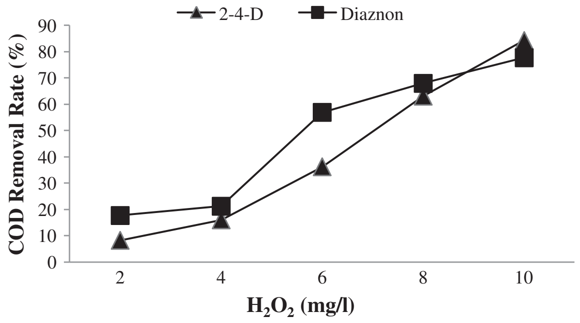

Fig. 4. COD removal in samples containing 2-4-D and Diazinon by adding different amount of $H_2O_2$.

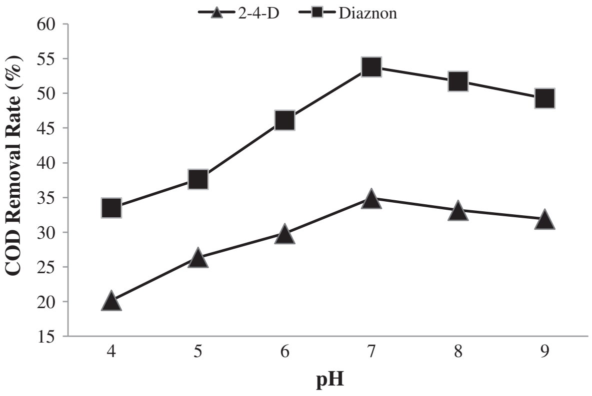

Fig. 5. Removal of 2-4-D and Diazinon by $H_2O_2$ in different pH.

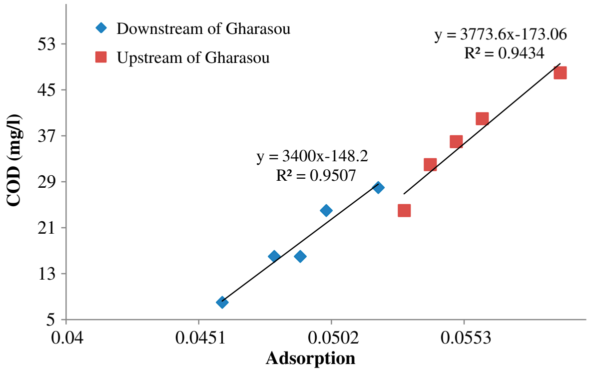

Fig. 6. Correlation between COD and adsorption of organic matter after adding various amounts of $H_2O_2$ to water of Gharasoo in two sampling points.

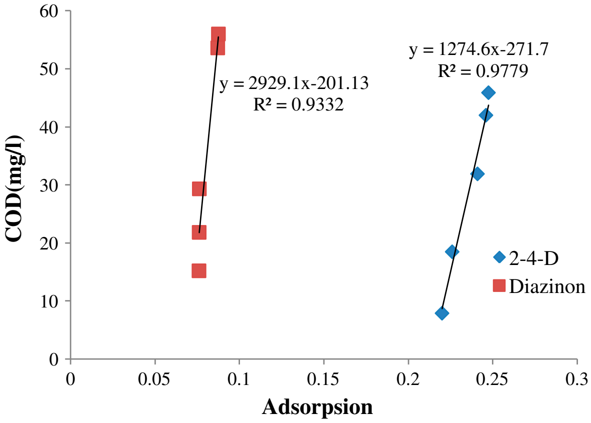

Fig. 7. Correlation between COD and Adsorption of organic matter after adding various amounts of $H_2O_2$ to samples containing 2-4-D and diazinon pesticides.

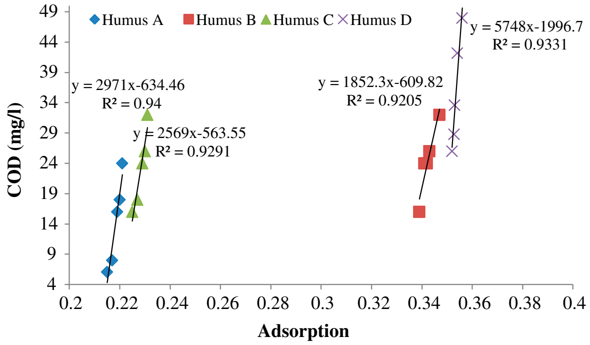

Fig. 8. Correlation between COD and adsorption of organic matter after adding different amounts of $H_2O_2$ to samples containing different types of humus.

hydrogen peroxide displayed the lowest adsorption for organic matter at the concentration of 10 mg/l (Figs. 6–8).

Direct correlations were observed between COD and organic matter adsorption for all the samples examined. Measuring the absorbance of samples containing organic materials in the wavelength of 253.7 nm is far more economic and time-efficient than COD measurements and it can be a good alternative for the measurements of COD. Thus, COD concentration can be calculated using relevant equations for each sample by measuring the absorbance.

## 4. Conclusion

Hydrogen peroxide is recommended as an efficient oxidizing agent due to the increasing organic matter concentration in surface waters in recent years and use of these resources as an important source of water supply in most urban areas. Since, COD concentration of less than 10 mg/l is used as drinking water; applying 5–10 mg/l of hydrogen peroxide to water treatment plants may greatly reduce the concentration of organic matter. Injections of this material in rapid mixing unit give the most consistent results as with the filtration unit.

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