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## Effect of Different Disinfecting Agents on Heavy Metals During Water Treatment

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### Authors' contributions

This work was carried out in collaboration between all authors. Author MAH designed the study, author AEES performed the statistical analysis, author WMK wrote the protocol, and wrote the first draft of the manuscript. Authors YHM and NEI managed the analyses of the study. Author MME managed the literature searches. All authors read and approved the final manuscript.

Research Article

Received 4<sup>th</sup> December 2012  
Accepted 13<sup>th</sup> March 2013  
Published 1<sup>st</sup> June 2013

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### ABSTRACT

**Aims:** The aim of this study to evaluate the effect of huwa-san and chlorine as disinfecting agents on heavy metals during water treatment.

**Place and Duration of Study:** Department of Biochemistry, Faculty of Pharmacy, October 6 university (Medical Unit IV) and Inorganic laboratory, Central laboratory, Greater Cairo Drinking Water Company, Fustat water treatment plant, between June 2012 and Jan. 2013.

**Methodology:** Nile water samples were taken from water intake throughout the fustat plant, treated with different doses of huwa-san and chlorine to evaluate their effect on the levels of water contained from Al, Zn, Cr, Ni, Fe, Pb and Cu.

**Results:** It was found that the treatment with huwa-san more effective than chlorine in

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decreasing Al, Zn, Cr, Ni and Cu at the most doses. Also, it is more effective than chlorine in decreasing Fe and Pb concentrations at the doses 2, 3, 4, 5 and 6 ppm while at the dose 7 ppm, the chlorine becomes more effective than huwa-san in decreasing concentration of these elements. Mn showed different results. The chlorine decreased Mn obviously more than huwa-san at all the doses. On the other hand, both of chlorine and huwa-san have the same effect on Zn only at the doses 2 and 3 ppm. The chlorine decreased Ni concentration more than huwa-san at the doses 2 and 3 ppm but huwa-san becomes more effective at the other doses. The results showed that the disinfection with huwa-san more effective results than chlorine at the same doses. 4 ppm of huwa-san represents the most suitable disinfection dose used during the treatment process.

**Conclusion:** The results showed that the disinfection with huwa-san more effective results than chlorine at the same doses. 4 ppm of huwa-san represents the most suitable disinfection dose used during the treatment process.

*Keywords: Disinfection; chlorine; huwa-san; heavy metals; water treatment.*

## 1. INTRODUCTION

Heavy metals may enter the river water from the geology of catchments soil. They are considered as common pollutants in aquatic environment. The heavy metals are a serious problem because of their toxicity and threat for human life [1].

River Nile is the main source for potable water and as the result of human activities in and on the river body, it become loaded by metal pollution. Total trace metals exhibited different behavior, with constant or increasing concentrations up river [2,3].

Huwa-San was produced as a disinfectant for biofilm removal. The previous study was restricted to evaluate with respect of Huwa-San capacity to remove the biofilm on pipe systems of drinking water [4]. It is based on silver stabilised hydrogen peroxide. Combination of hydrogen peroxide and silver resulting in products showing a synergistic biocidal activity [5]. Fe, Zn, Cd and Pb are more widely distributed. Fe is a component of iron-porphyrins haem and ferroxins and it is essential for growth and well being of living organisms [6]. Zinc has low toxicity to man, but relatively high toxic to fish. Toxicity of high level zinc concentrations in man is well known [7].

Cadmium has been found to be toxic to fish, and other aquatic organisms [8]. The effects of Cd toxicity in man include many diseases [9,10]. Lead is defined by the United State Environmental Protection Agency (USEPA) as potentially hazardous to most forms of life. It has no known beneficial biochemical attributes [11].

Some heavy metals as Co, Cu, Fe, Mn, Ni and Zn are essential elements required for normal growth and metabolism. These elements can easily lead to poisoning when their concentration rises to supra-optimal values. They may cause alterations in numerous physiological processes at cellular/molecular level by inactivating enzymes, blocking functional groups of metabolically important molecules, displacing or substituting for essential elements and disrupting membrane integrity. A rather common consequence of heavy metal poisoning is the enhanced production of reactive oxygen species (ROS) due to interference with electron transport activities [12,13].

## 2. MATERIALS AND METHODS

### 2.1 Nile Sample

Nile water samples were taken from water intake throughout the fustat plant water treatment plant. The Nile water did not undergo any treatment step. The experiment repeated several times using Nile sample taken from the same site of the Nile River Fig.1.

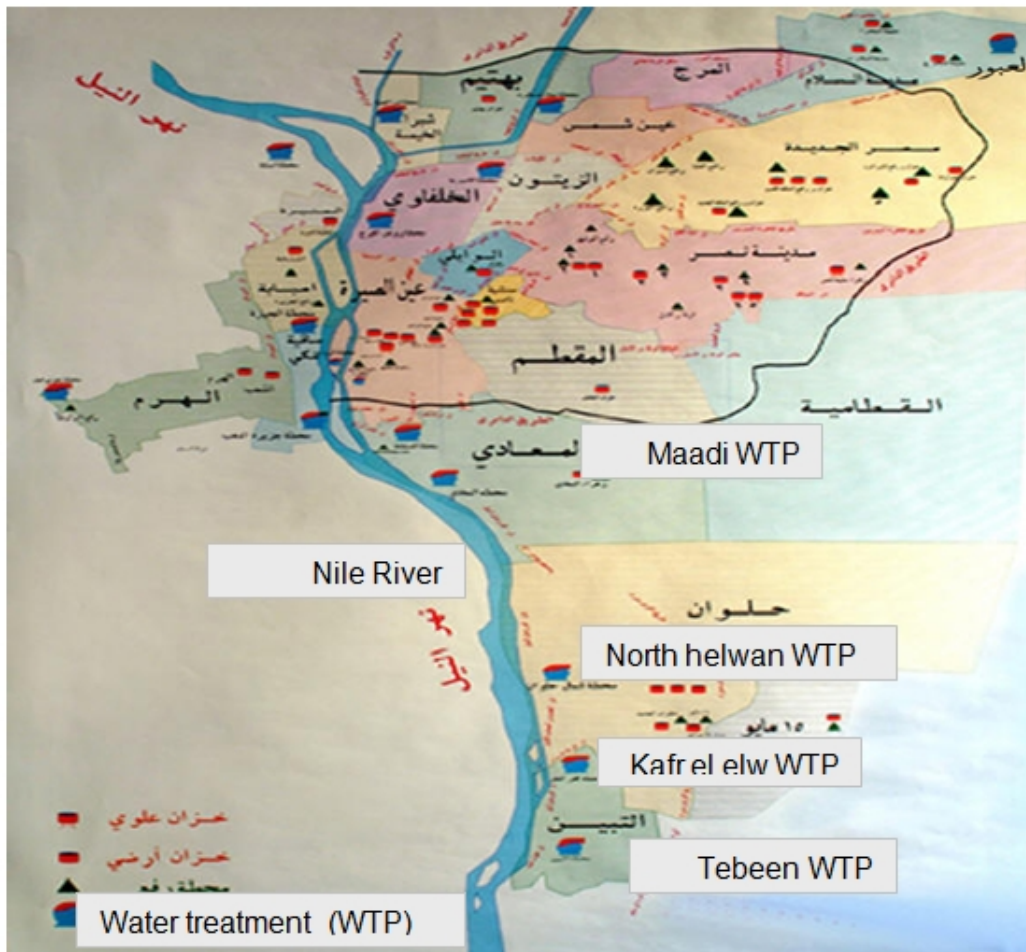


Fig. 1. Map showing the location of the river and the stations

### 2.2 Jar Test

Six liter beakers were filled with Nile water. Different concentrations of chlorine added individually to each beaker. Concentration of chlorine solution was 1%. 1ml of chlorine solution added to 1 L of Nile water to make concentration 1 ppm. The other chlorine doses added in the same manner. 30 ppm  $Al_2(SO_4)_3$  added to each beaker. The contents in each beaker were mixed well at speed 120 rpm for 10 min. then mixed at speed 20 for 30 min. [14,15].

### 2.3 Chlorine Dosing

Nile water samples were dosed with sodium hypochlorite solution (1% - 10 mg L<sup>-1</sup>). All waters were dosed at six different chlorine concentrations including 2, 3, 4, 5, 6 and 7 ml.

### 2.4 Huwa-san Dosing

Nile water samples were dosed with Huwa-San solution (1%) at the same dose as chlorine undergoing the same mechanism of chlorination process. There was no free chlorine to be measured.

### 2.5 Measurements

The heavy metals including Aluminium, Manganese, Iron, Zinc, Cadmium, Lead, Chromium, Nickel and copper required to be digested by adding 1 ml of concentrated nitric acid purchased from Aristar Co. The digestion occurs to convert these metals to the nitrated form to be measured. Samples were preserved immediately after collection by acidifying with concentrated HNO<sub>3</sub> to pH<2 by adding 5 ml nitric acid to 1 liter water samples. After acidification, the samples possible to be stored in refrigerator.

The digestion was carried out in the microwave using ultraviolet light to convert all the metals into the nitrated form. The digestion may occur by hot plate. 100 ml of sample mixed with 2 ml Conc. HNO<sub>3</sub> in a beaker at hot plate. It allowed evaporating till volume become 20 ml. The volume completed to 100 ml with dist. H<sub>2</sub>O. portion of this solution taken to be analyzed. This process occurred according to method of metals determination by Inductive Coupled Plasma – Mass spectrometer System (ICP-MS) which was manufactured by Varian Co [16]. The metals were measured by the instrument from the calibration curve plotted automatically by software.

## 3. RESULTS AND DISCUSSION

The data in the Table 1 showed effect of chlorine and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Al, Mn and Fe. All the samples were compared to the Nile water. As shown in the Fig. 2, it was found that the treatment with huwa-san decreased Al concentration obviously more than chlorine. The dose 3 ppm is the most effective dose in huwa-san while 7 ppm is the most effective with chlorine.

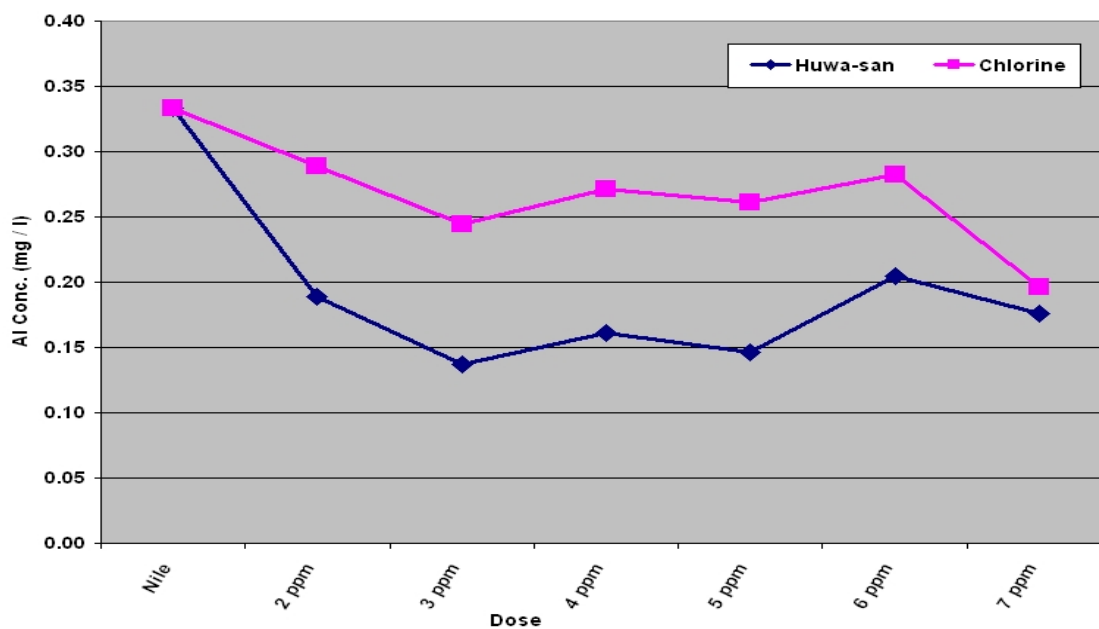
Fig. 3 showed that chlorination is more effective at all the doses than treatment with huwa-san in decreasing Mn concentration. The dose 7 ppm was the most suitable dose on Mn with both of chlorine and huw-san.

**Table 1. Effect of chlorine and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Aluminium, Manganese and Iron.**

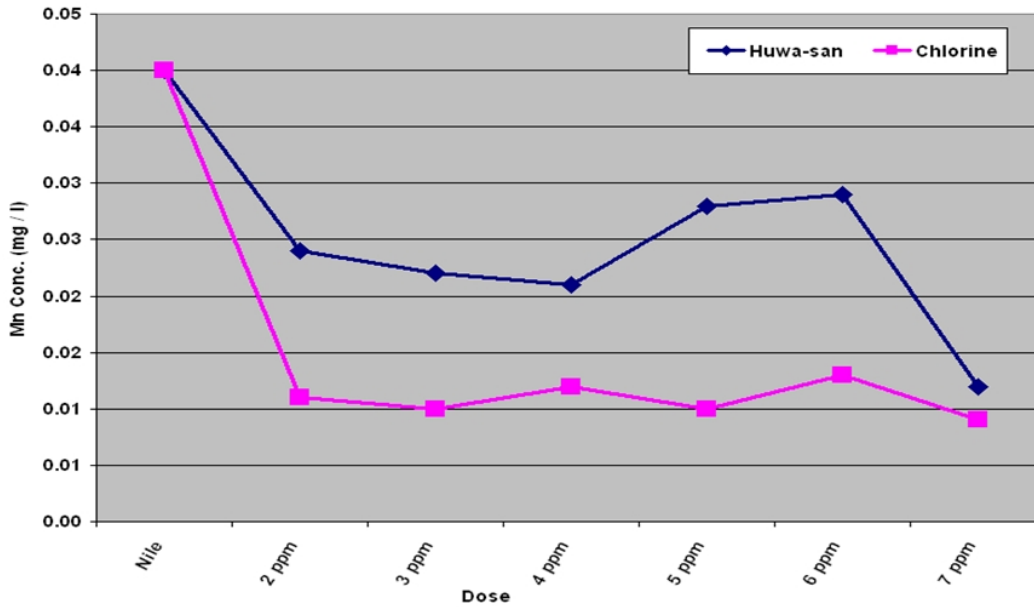
	Nile	2 ppm		3 ppm		4 ppm		5 ppm		6 ppm		7 ppm	
		Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.
Al (mg/l)	0.33	0.19	0.29	0.14	0.24	0.16	0.27	0.15	0.26	0.21	0.28	0.18	0.20
Mn (mg/l)	0.04	0.02	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.03	0.01	0.01	0.01
Fe (mg/l)	0.47	0.03	0.06	0.02	0.10	0.02	0.13	0.02	0.11	0.04	0.08	0.09	0.05

Hu : Huwa-san 25

Chlor. : Chlorine

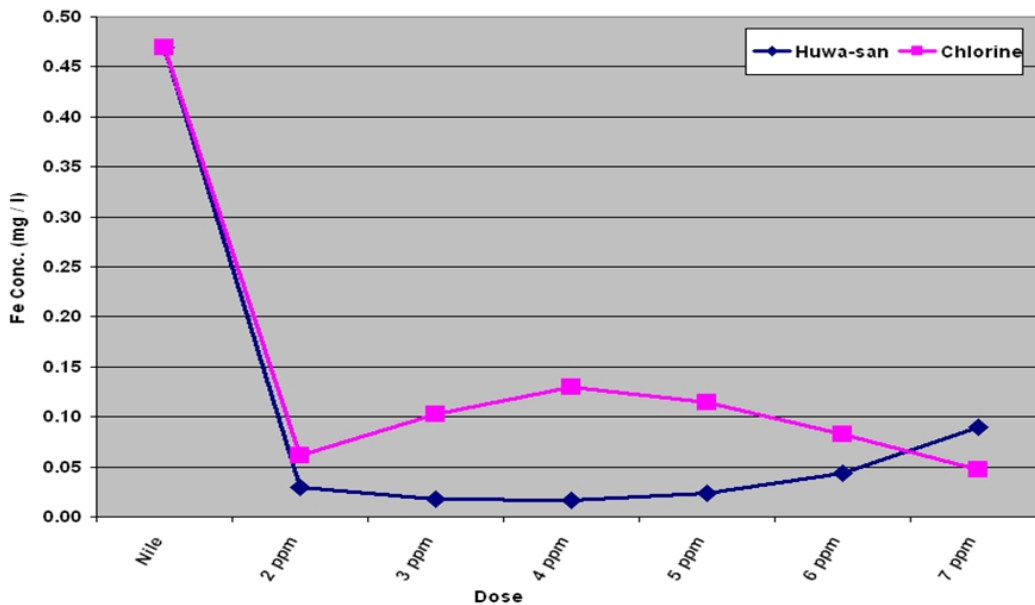


**Fig. 2. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Aluminium concentration**



**Fig. 3. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Mn concentration**

As shown in the Fig. 4, it was found that the treatment with huwa-san decreased the Fe concentration more than chlorine especially at the doses 2, 3, 4, 5 and 6 ppm. The huwa-san became less effective at the dose 7 ppm than chlorine in decreasing the Fe concentration.



**Fig. 4. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Fe concentration**

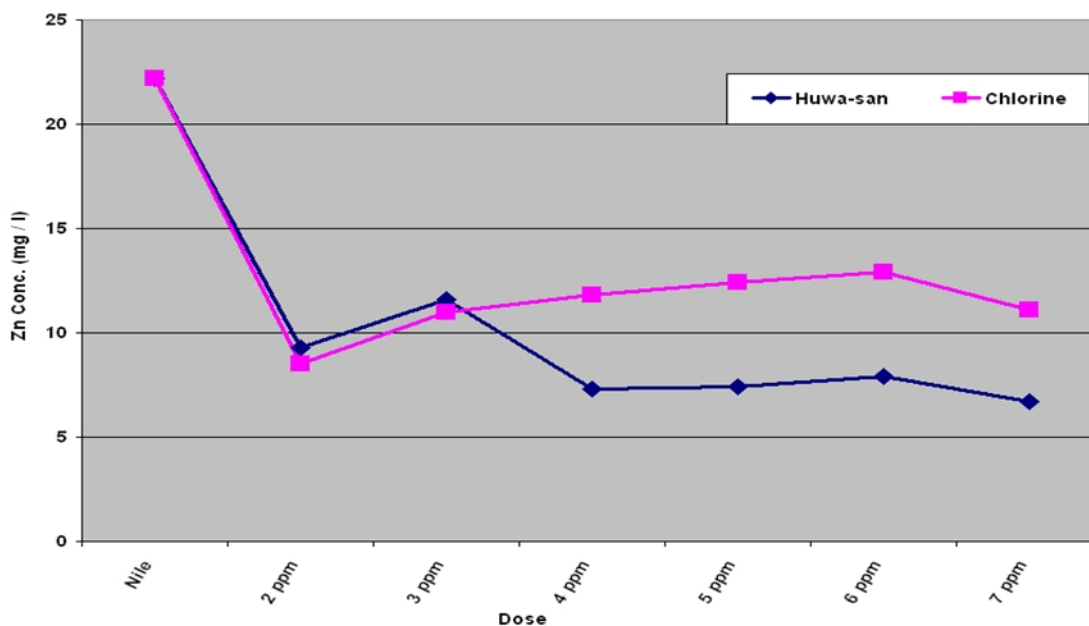
The data in the Table 2 showed that there is no cadmium detected in the Nile water and treated water with chlorine or huwa-san.

**Table 2. Effect of chlorine and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Zinc, Cadmium and Lead**

	Nile	2 ppm		3 ppm		4 ppm		5 ppm		6 ppm		7 ppm	
		Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.
Zn (mg/l)	22.2	9.3	8.5	11.6	11	7.3	11.8	7.4	12.4	7.9	12.9	6.7	11.1
Cd (µg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb (µg/l)	1.2	0.5	0.5	0.4	0.5	0.3	1	0.4	0.5	0.4	0.6	0.5	0.3

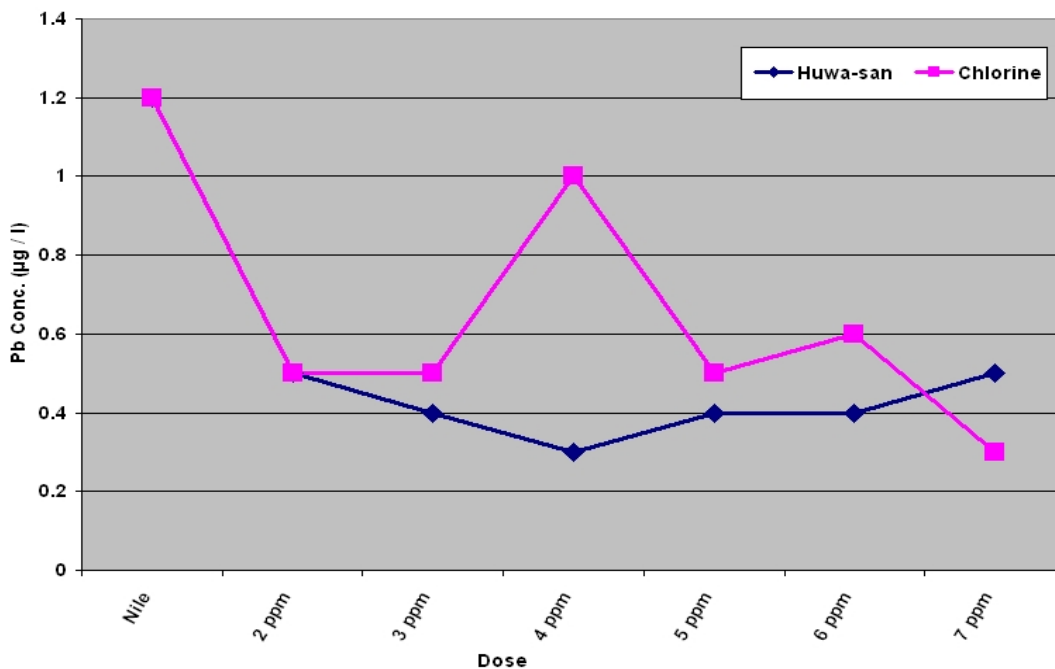
Hu. : Huwa-san 25  
 Chlor. : Chlorine

As shown in the Fig. 5, it was found that the treatment with huwa-san decreased Zn concentration obviously more than chlorine especially at the doses 4, 5, 6 and 7 ppm. The chlorine and huwa-san have the same effect on Zn concentration approximately at the doses 2 and 3 ppm.



**Fig. 5. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Zn concentration**

The data illustrated in the Fig. 6 showed that the chlorine and huwa-san have the same effect on Pb concentration at the dose 2 ppm. The disinfection with huwa-san decreased the Pb concentration more than chlorine especially at the doses 3, 4, 5 and 6 ppm. While chlorine became effective at the dose 7 ppm in reduction of the Pb concentration more than huwa-san.



**Fig. 6. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Pb concentration**

The data in the Table 3 showed effect of chlorine and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Cr, Ni and Cu. The data graphically illustrated in the Fig. 7, showed that the treatment with huwa-san decreased Cr concentration obviously more than chlorine at all studied doses. 5 ppm is the most effective huwa-san dose in decreasing Cr concentration.

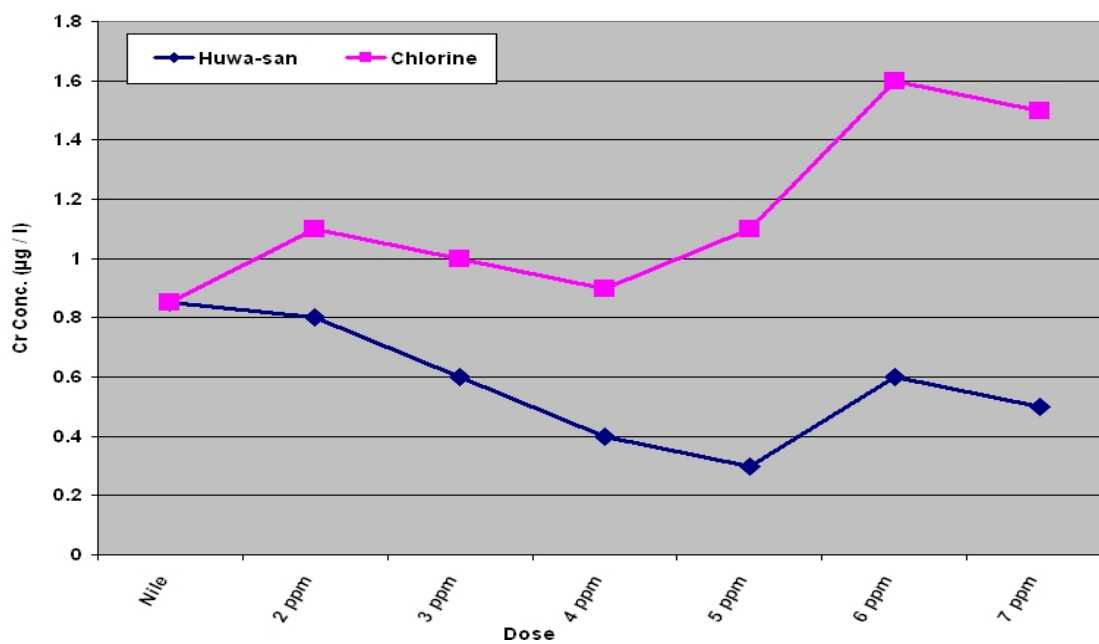
The Fig. 8 showed that chlorination decreased Ni concentration effectively more than huwa-san at the doses 2 and 3 ppm. While huwa-san became more effective in decreasing concentration of this metal at the doses 4, 5, 6 and 7 ppm. As shown in Fig. 9, it was found that the disinfection with huwa-san decreased concentration of Cu at all studied doses effectively more than chlorine. 3 ppm is the most suitable huwa-san dose in decreasing concentration of this metal.



**Table 3. Effect of chlorine and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Chromium, Nickle and Copper**

	Nile	2 ppm		3 ppm		4 ppm		5 ppm		6 ppm		7 ppm	
		Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.	Hu	Chl.
Cr (µg/l)	0.85	0.8	1.1	0.6	1	0.4	0.9	0.3	1.1	0.6	1.6	0.5	1.5
Ni (µg/l)	1.5	1.4	1.3	1.4	1.2	1.2	1.7	1.6	2.2	1.2	1.7	1.3	1.6
Cu (mg/l)	0.4	1.7	2.5	1.4	2.8	3.7	4.1	2.6	4.3	1.9	4.1	1.8	3.7

Hu. : Huwa-san 25  
Chlor. : Chlorine



**Fig. 7. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Cr concentration.**

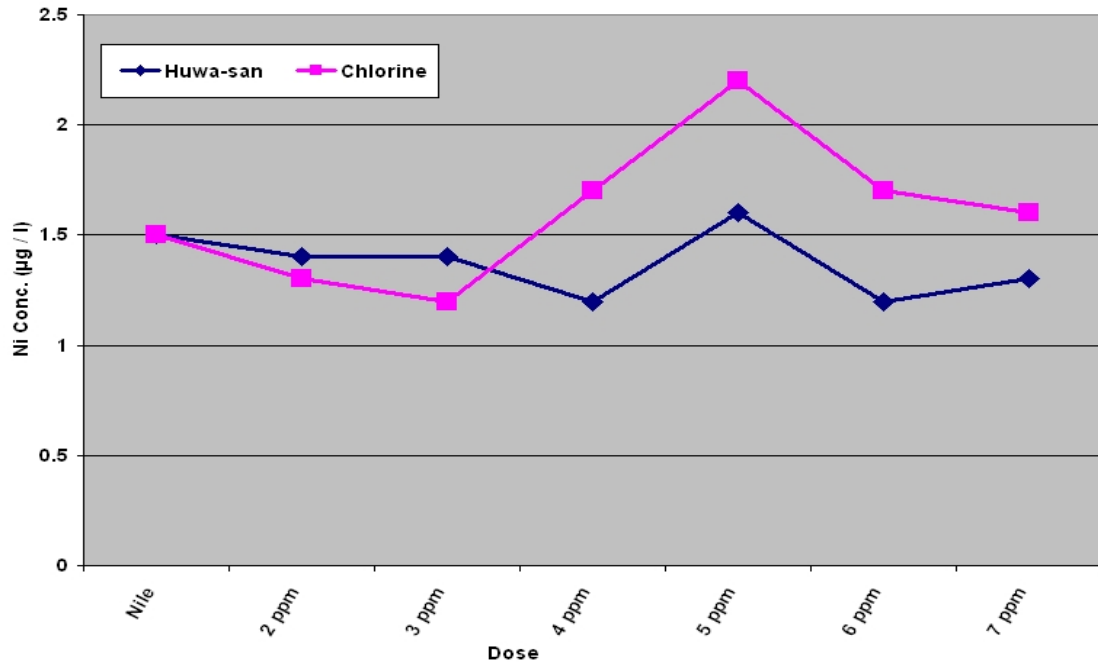


Fig. 8. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Ni concentration

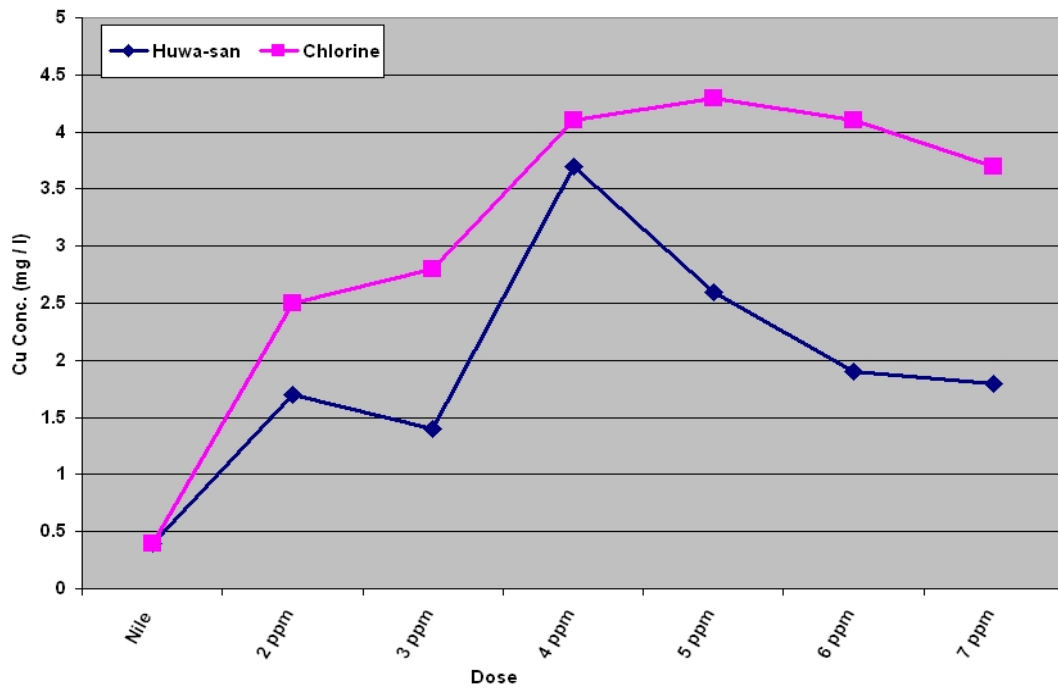


Fig. 9. Chart showing comparison between chlorination and huwa-san at the doses 2, 3, 4, 5, 6 and 7 ppm on Cu concentration

The heavy metals especially Fe, Zn, Cd and Pb increased in the natural aqueous systems due to high content natural and anthropogenic organic matter which may concentrate in the surface film. This may occur due to its surfactant and correlation properties and stabilize trace metals by complexation [11,17]. These metals may increase in water due to lowering pH and increasing temperature [18] and / or due to ability of some metals to form very stable dissolved complexes as in case of lead [19,20]. On other hand, the heavy metals decrease in natural aqueous systems due to surface adsorption of metallic element by colloidal Fe<sub>2</sub>O<sub>3</sub> naturally occurring in water streams [21].

The heavy metals decreased in the surface water especially Fe due to undergoing oxidation-reduction reaction [11].



So, Fe may exist as Fe<sup>2+</sup> or Fe<sup>3+</sup>. Both oxidation and alkalinity conditions promote precipitation of Fe, while both reduction and acidic promote its dissolution. Iron precipitated as Fe(OH)<sub>3</sub> which can absorb many trace metals [21]. For this reason, huwa-san caused decrease in Fe concentration more than chlorine.

Fe and Mn appear associated together and originate from a common source during transportation and/or depositional reactions. They undergo the same reaction mechanism during the disinfection process [22].

The Zn correlated positively with each of Fe and Mn. These are due to the Zn adsorption by hydrous iron and manganese oxides. In addition, Zn is correlated positively with Cu and Pb [2].

The heavy metals especially Fe, Mn, Zn, Cu and Pb decrease with decreasing the suspended particles. The total solids showed significant positive correlation with total Fe, Mn, Zn, Cu and Pb, where suspended matter contains several types of substances; Fe and Mn oxides, clays and organic detritus. These compounds play a role by providing active surface upon which trace metals can absorb [23].

The increase in Pb concentrations in the Nile water might be attributed to the direct inputs from different sources (industrial wastes and atmospheric inflow of dust containing car exhaust). In addition, the increase in density of boats and ship, which discharge its effluent directly to the Nile containing high amount of Pb in both the dissolved and particular phases [3,24]. The treatment with huwa-san showed more effect than chlorine in decreasing Pb concentration.

Removal of these metals is characterized by the formation of the metal chlorides. 90% of Pb, Zn, Cu and Cd can be removed from the water under in form of meal chlorides. The fraction of metal removed is determined mainly by the relative stabilities of the metal chloride [25].

#### 4. CONCLUSION

The results showed that the disinfection with huwa-san more effective results than chlorine at the same doses. 4 ppm of huwa-san represents the most suitable disinfection dose used during the treatment process.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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