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Assessment of Drinking Water Treatment based on Free Residual Chlorine in Rabak Town – White Nile State – Sudan 2010

Belal Abdallah A. Adam (Ph. D)
Assistant Professor,
Shendi University, Faculty of Public Health,
Environmental Health Department,
Shendi , Sudan

Basheer Mohammed Elhassan (Ph. D)
Associate Professor,
University of Khartoum,
Faculty of Engineering, Chemical Engineering Department,
Khartoum, Sudan.

Dawria Adam (Ph. D)
Assistant Professor,
Shendi University, Faculty of Public Health,
Public Health Department,
Shendi, Sudan.

Ahmed M. Hussein (MPH)
Senior Lecturer,
Shendi University, Faculty of Public Health,
Public Health Department,
Shendi, Sudan.

Abstract **- Dirty and polluted water can contain many harmful agents. These can cause diseases and many health problems. Treatment of water aims to remove these pollutants and causatives of diseases. This study aims to assess drinking water quality based on free residual chlorine, after collection of samples from different locations: plant of treatment and distribution system (12 represented samples) then all samples were analyzed immediately. The study revealed that 33.3% of samples showed free residual chlorine as 0.1mg/L and 66.7% of samples demonstrated it absence, while WQI (water quality Index) according to free residual chlorine is 6.7. All analyzed samples showed that pH of water were in normal range (6.5-8.5). While WQI based on pH indicated the water quality ranged 25% of samples bad and 75% of samples medium. Throughout the results of this study observed treatment of drinking water is insufficient and pH of water is appropriate for chlorination. The study recommended that more chlorine must be added for proper treatment process.**

Keywords: Treatment, Residual, Chlorination, Water Quality, Harmful, Rabak Town.

I. INTRODUCTION

Water can be treated at various stages between the source and the end users, a limited number of technologies can be applied at source but most are used after water has been abstracted (IWSC, 2006). The final stage in the water treatment process is disinfection that defined as the process by which an article, surface or medium is made water free from all pathogenic microorganisms that are capable or giving rise to infections (Statish, 2002).

Chemical disinfectants for water should be having the following attributes:

* Destroy all pathogens present in water within an acceptable amount of time.
*Be able to perform within the range of temperatures and physical conditions encountered.
*Disinfect without leaving any harmful substances in water.
*Permit simple and quick measurement of strength and concentration.
*Leave sufficient active residual concentration as a safe guard against post treatment contamination.
*Ready and dependable availability at a reasonable cost (Oxfam, 2001).

*Factors affecting disinfection :*The principal factors that influence disinfection efficiency are:
*Disinfectant type and its concentration
*Contact time (CT) this important for chemical disinfectants
*Temperature of the water (High temperature speed up chemical reactions
*PH of the water
*Kind and concentration of microorganisms in water

* Other constituents of the water which may impede disinfection or render it impossible, also there are some constituents that react with chlorine such as iron and manganese compounds, ammonia compound (forming chloro amines) as well as numerous organic particles. The presence of these substances reduce the germicidal effect considerably (SSMO, 2006; Steven, 2005).

Chlorination: Chlorination the most important technological development in the water treatment, during the twentieth century introducted in 1908, it provides a cheap reproducible method of ensuring the bacteriological quality of drinking water (Moeller, 2005). Chlorination can be achieved using liquefied chlorine gas, sodium hypo chlorite, solution or calcium hypochlorite granules and on-site chlorine generators (WHO, 2004).

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Chlorine: Chlorine is the one of the most widely used chemicals for microbial control in drinking water treatment process; it is powerful antimicrobial substance due to its potential oxidizing capacity in addition to drinking water disinfection (Virto et al. 2005). Chlorine is widely used as a disinfectant; it is commercially available as calcium hypochlorite powder (solid), sodium hypochlorite (liquid) or as chlorine gas. Chlorine is very active and reacts quickly with organic and inorganic matter in water. For disinfection is to be achieved, due allowances must be time –wise and quantity-wise for the chlorine to react with other compounds like ammonia, metal iron, and organic compound (WHO, 2002). The amount of chlorine required depends on organic matter and harmful organisms in water, the dose should be leave residual level of chlorine (0.2-0.5 mg/L).

Mode of chlorine action: Chlorine gas and water react to form hypochlorous acid (HOCL) and hypochloric acid (HCL). In turn HOCL dissociated into hypochlorite ion (OCL) and hydrogen ion (H) according to the following reactions:

$$*CL2 + H2O \longleftrightarrow HOCL + HCL$$

$$*HOCL \longleftrightarrow H^{\dagger} + OCL^{-}$$

The reactions are reversible and PH dependent.

*Between PH 3.5 and 5.5 HOCL is predominant species

*Between PH 5.5 and 9.5, both HOCL and OCL ion species exist in various proportions

*Above PH 8 OCL predominant (WHO, 2004). The disinfection action of chlorine is mainly due to hypochlorous acid, and to a small extent due to the hypochlorite ion, the hypochlorous acid (HOCL) is the most effective form of chlorine water disinfection. It is more effective (70-80 times) than hypochlorite ion (Park, 2005). The PH of the water it's critical for effective chlorination where the PH is too high, chlorine will be consumed in reactions to restore the PH back to neutral. In general, the optimum range of PH for chlorination is 6.5-8.5 (Howard, 2002).

water quality index: Water quality Index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water. It reduces the large amount of water quality data to a single numerical value (Vasanthavigar , et.al , 2010).

3.10.1 Calculation of Water Quality Index

Water quality index [WQI] = QiWi/Wi

Where, Qi is water quality rating

Qi = 100*[Va-Vi]/[Vs-Vi]

Va = Actual value of the parameters present in water sample

Vs = Standard value

Vi = ideal value

Wi = K/Sn , Where Wi = Unit weightage

K[constant] = 1/[(1/S1) + (1/S2) + (1/S3) + ….. + (1/Sn)

(Maruthi Devi, et al.2010).

WQI has been classified into five classes according to national sanitation foundation in the following table:

WQI range	Quality of water
0-25	Very bad
26-50	bad
51-75	medium
76-100	good
Above 100	excellent

II. MATERIALS AND METHODS:

study area: Rabak town is the capital of White Nile state; it lies in the eastern bank of White Nile channel. Geographically it lies between two lines length32-33 north and two lines width 12-13 East. Rabak Town distance from Khartoum Town (capital of Sudan) about 360 kilometers.

Sample Size: Determination of samples were completed according to WHO guidelines for drinking water quality in distribution system (1993) volume one and manual of standards of quality for drinking water supplies (12 samples).

Equipment, materials, and apparatus: Sample's Bottles made of plastic, Max pencils for labeling bottles of samples, pH meter for measuring pH of water, Chlorine meter for measuring free residual chlorine, Tube test capacity of 10 ml, Cell for water sample, Electrode solution and reagent (chlorine tablets free) as indicator.

Analysis of samples: After collection of samples from different locations at Rabak Town they were analyzed in laboratory by certain methods: for residual chlorine we used commercial visual comparator technique. And For pH we measured it by using the electronic method which required an electronic PH meter and electrode, and PH buffer solution at PH 7.0 and 9.0.

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III. RESULTS

Table (1) free residual chlorine and pH for drinking water samples

Sample No	Location of sampling	Free residual chlorine mg/L	pH
S_1	Treatment plant	Nil	7.5
S_2	Treatment plant	Nil	7.9
S_3	Treatment plant	0.1	7.9
S_4	Block 20	0.1	7.5
S_5	Block 5	Nil	7.9
S_6	Block 4	Nil	7.8
S_7	Block 6	0.1	7.9
S_8	Block 16	0.1	7.8
S_9	Block 29	Nil	8.0
S_{10}	Block 12	Nil	7.9
S_{11}	Block 1	Nil	7.7
S_{12}	Block 14	Nil	7.9

The above table shows that free residual chlorine ranged from Nil to 0.1 mg/L and pH ranged from 7.5 to 8.0

Table (2) WQI for drinking water samples based on free residual chlorine

samples	Va	Vi	Vs	Va - Vi	Vs - Vi	K	qi	wi	Qi*wi	wqi
S_1	0	0	0.5	0	0.5	1	0	2	0	0
S_2	0	0	0.5	0	0.5	1	0	2	0	0
S_3	0.1	0	0.5	0.1	0.5	1	20	2	40	20
S_4	0.1	0	0.5	0.1	0.5	1	20	2	40	20
S_5	0	0	0.5	0	0.5	1	0	2	0	0
S_6	0	0	0.5	0	0.5	1	0	2	0	0
S_7	0.1	0	0.5	0.1	0.5	1	20	2	40	20
S_8	0.1	0	0.5	0.1	0.5	1	20	2	40	20
S_9	0	0	0.5	0	0.5	1	0	2	0	0
S_{10}	0	0	0.5	0	0.5	1	0	2	0	0
S_{11}	0	0	0.5	0	0.5	1	0	2	0	0
S_{12}	0	0	0.5	0	0.5	1	0	2	0	0
sum.∑								24	160	6.7

The above table shows that WQI ranged from 0-20 and general WQI is 6.7 (very bad).

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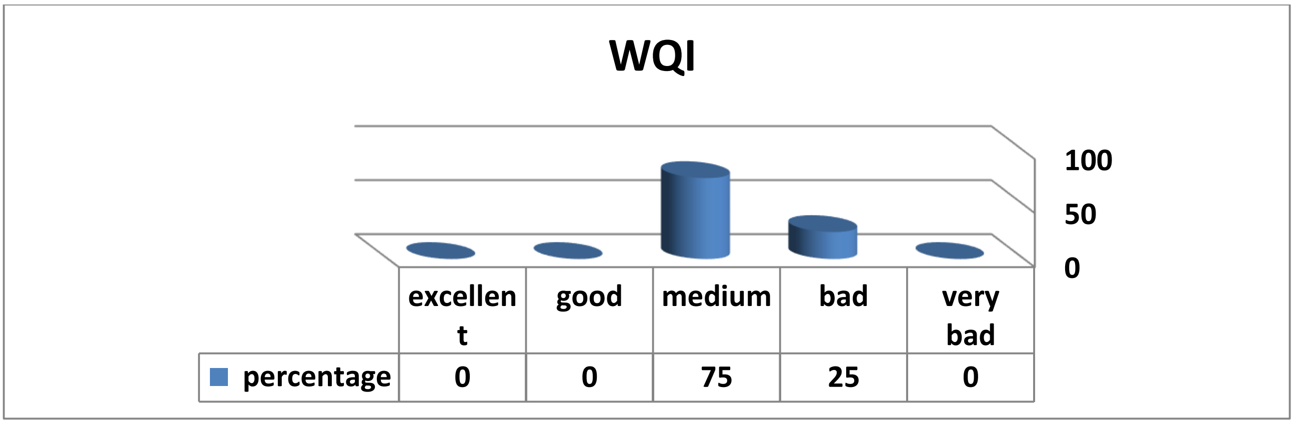
Table (3) WQI for drinking water samples based on pH parameter

samples	Va	Vi	Vs	V_a - V_i	V_s - V_i	K	qi	wi	Qi*wi	WQI
S_1	7.5	7	8.5	0.5	1.5	1	33.3	0.12	3.9	33.3
S_2	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
S_3	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
S_4	7.5	7	8.5	0.5	1.5	1	33.3	0.12	3.9	33.3
S_5	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
S_6	7.8	7	8.5	0.8	1.5	1	53.3	0.12	6.3	53.3
S_7	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
S_8	7.8	7	8.5	0.8	1.5	1	53.3	0.12	6.3	53.3
S_9	8.0	7	8.5	1	1.5	1	66.7	0.12	7.8	66.7
S_{10}	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
S_{11}	7.7	7	8.5	0.7	1.5	1	46.7	0.12	5.5	46.7
S_{12}	7.9	7	8.5	0.9	1.5	1	60	0.12	7.1	60
sum.∑								1.41	76.1	54

The above table shows that WQI ranged between 33.3 to 66.7 and general WQI is 54 (medium).

Figure (1) WQI for drinking water samples based on pH parameter



The above figure shows that 75% of samples were indicated the water quality is medium and 25% of them were indicated the quality of water is bad.

IV. DISCUSSION:

The present study revealed that 25% of examined samples free residual chlorine is 0.1mg/l and in 75% of samples is Nil, this concentration (0.1mg/l) is insufficient for removal of pathogens due to high levels of contaminants in surface water. the evidence of insufficient of treatment (75% of samples) were showed absence of free residual chlorine this means all chlorine has been consumed by contaminated matters, thus we expected found many of pathogens in this water. Systems that maintained dead-end free chlorine levels of less than 0.2mg/l had substantially more coli form occurrences than systems maintaining higher disinfectant residual (WHO, 2004), this point support this study throughout the results. In previous study done by (Chen & Stewart, 1996) showed free chlorine is essentially consumed before it can react with bacterial components of the film.

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The present study revealed that quantity of using chlorine is insufficient because most of samples were indicated no free residual chlorine , chlorine must be adding till it can removes all contaminants and there are remaining ranged 0.2- 0.5 mg/l to efficiency of chlorination process and control of microbial regrowth in distribution system of water supply.

When chlorine is used as disinfectant in piped distribution system, it is desirable to maintain a free chlorine residual of 0.2-0.5 mg/l to reduce the risk of microbial regrowth and the health risk of recontamination (WHO, 2004). The study showed that the PH of water ranged 7.5- 8.0 (table1) this value is acceptable and appropriate for disinfection, because the guideline value of optimal PH for drinking water in range 6.5-8.5. While WQI based on pH indicated that drinking water quality is medium in 75% of samples (figure 1). But WQI based on free residual chlorine showed that quality of drinking water is very bad (table 2).

Conclusion:

All people whatever their stage of development and social and economic conditions, have the right to have access to drinking water in quantities and of quality equal to the basic needs, throughout the results of this study we observed treatment of drinking water is insufficient and pH of water is appropriate for chlorination drinking water by suing chlorine as disinfectant.

Recommendations:

According to results of this study it is recommended that more chlorine must be added for proper treatment process and local health authorities must check drinking water supply system regularly according to WHO guidelines for drinking water safety.

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