Australian Journal of Basic and Applied Sciences, 6(9): 510-516, 2012
ISSN 1991-8178

Sustainability and Performance Evaluation of Drinking water Treatment plants: A case Study in Iraq of Al-Krama Project

[1]Ali Ahmed Mohammed, [2]Shayma A. Shaker and [3]Alaa A. Shakir

[1]Reconstruction and Project Department, Ministry of Higher Education and Scientific Research, Iraq
[2]Department of Sciences and Mathematics, Universiti Tenaga Nasional, KM 7 Jalan Kajang-Puchong, 43009 Kajang, Selangor, Malaysia,
[3]Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional, KM 7 Jalan Kajang-Puchong, 43009 Kajang, Selangor, Malaysia

Abstract*:* Al-Krama drinking water treatment plant has been playing a vital role in supplying drinking water to Baghdad city since 1980s. It was designed with a design capacity 22500 m^3/d so that it can cover the needs of the public properly. However, the fatal circumstances which have recently hit Baghdad city represented by wars and terrorist operations have considerably resulted in a significant deterioration in the quality of Al- Krama water treatment plant in the early of 2005s and 2006s. Furthermore, the failure of the equipments and the deficiency of the crew of the power plant have dramatically caused a shortage in the efficiency of the plant. Therefore, this work is the earliest attempt in addressing the problem of this plant. In this study, the removal efficient of the filtration, sedimentation will be addressed as well as the turbidity during three years of investigation. It was found that the average value of the removal of the sedimentation basin was about 24% which is obviously low due to the absence of the permanent maintenance and the continuous clean out for the sedimentation basin. The removal efficiency of filtration basin was as high as 85% comparatively with the removal efficiency of the sedimentation basin .The turbidity magnitudes were slightly oscillated along the study period since there has been shortage in the efficiency of sedimentation basin; it is then peaked at rainy season with about 20 $_{NTU}$. The free chloride (CL_2) was high but it may fall within the parameters, it is interesting to note that it was highly increased at September and December due to the high turbidity discharge.

Key words: sustainability water treatment drinking plant, Performance assessment, performance Indicators.

INTRODUCTION

Drinking water treatment plant is the most vital infrastructure since it serves industrial, domestically and agricultural sectors. The water resources since has been an enthusiastic field since ages. Various researches were held on analyzing the water webs (Ali, 1993; Allayla *et al*., 1985). In many cases drinking water was incorrectly treated resulted in the trail of epidemics diseases which threaten the health of human potential (Alobaidi, 2005; Amirtharajah *et al*., 1980; Amirtharajah, 1988).

The main objective of water treatment is to purify the polluted water and make it fit for the human consumption, through the removal and killing of organism's sickness (pathogenic organisms) and remove the taste, smell, unpalatable brownish discharge, some of the excess of dissolved metals and a range of items (Amirtharajah, 1989; Black *et al*., 1961). The validity of the water for human consumption is a measure of the purity of water as well as compared with the water consumption for industrial and agricultural sectors. However, some industries require high purity water like pharmacological industry and paper industry (Black *et al*., 1963).

Potable water for human consumption contains permitted concentration of impurities, particulates, chemical compounds and minerals dissolved water treatment (Chambers *et al*., 1995). Moreover, it contains the number of bacteria in source water and like colon bacteria (*E-coli*), also included the parameters of the highest amounts of radiation in the presence of water (Kavanaugh *et al*., 1980). Some developed countries identified the concentration of water allowed by the World Health Organization standards (WHOS), which is more complicated than conventional treatment, leads to an increase in cost (Kawamura, 1976). However, costs do not represent an impediment to these countries especially for developed countries as Japan which has made strict methods in water treatment plant (Logsdon, 1987).

The World Health Organization had done some arrangements to enhance the capacity of water treatments plant as establishing the stations in the form of story in order to exploit the area, establishing the internal walls of the basins of the treatment where algae can't growth. Pan-American Health Organization has identified the highest concentration of turbidity permitted by (1_{NTU}) in 2003 of water turbidity actual centers in American

Corresponding Author: Ali Ahmed Mohammed, Reconstruction and Project Department, Ministry of Higher Education and Scientific Research, Iraq.
E-mail: aliukm@yahoo.com

cities of Amount (0.1_{NTU}) (Rooks, 1974). Keep in mind that the seasonal events such a spring runoff, summer and fall algae blooms, and soil erosion affect final effluent quality. It was indicated that influent turbidity to the water plant is high during rainy periods (Se´rodes *et al*., 1996). Moreover, rivers are more susceptible to pathogen contamination than lakes and reservoirs, besides higher particulate concentrations. It was found that the water color highly affects the sizing of the particles and Giardia cysts as measured by the particle counter. The level of pathogens, such as Giardia and Cryptosporidium, in the filtered water is related to their respective levels in raw water (Viessman *et al*., 2005).

Description of the Station:
Description of the Project:

The results obtained in this study were taken from Al-Krama water treatment plan on the banks of the Tigris River, Utaifiyya, Bahghdad. Iraq. The project consists of three lines of water filter with design capacity 225000 m^3/ day. The first line was established in the early of 1953, the second and third lines were established in 1962 and 1983 respectively. Al- Krama water treatment plant serves many cities as Utaifiyya, Kadhimiya, Aldjaevr, Haifa Street, a portion of Alhurriay city, Adhamiya and a part of Alshalla. Tests were conducted from the third line which has design capacity around 112 500 m^3/ day. Flow diagram of Al-Krama treatment plant is illustrated in Fig.1 and Fig.2.

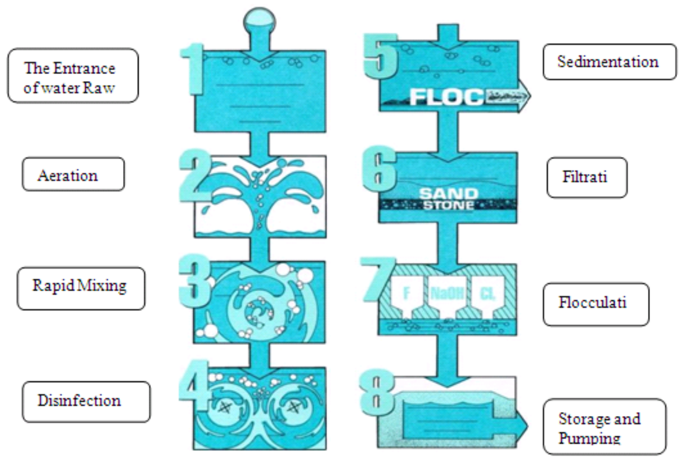

Fig. 1: Water treatment plant stages with respect to the type of filter.

Intake:

It is located on the Tigris River in depth of 9 meters, a rubber protector to prevent the entry of floating material and algae. The pump contains 5 plugs on the pump uploaded the water, four of them working and the fifth-pump is as Standby. The total energy of each pump is 1470.6 m^3/ h, the pressure of the head of the water is 20 m, and the type of the pump is (KSP RDL 400-440A). These pumps are meant to raise the water from the river to the Rapid mixing basin. There is an organized system near the lift station in order organize the amount of water drawn from river.

The Purification Process:
The Rapid Mixing Stage:

It is the first treatment step for water after receives it from river. Chemical additive as aluminum is added to the raw water materials in a manner and then distribute the water to the sedimentation basins. Dimensions of the pelvis (6×5.6×4) m and the actual capacity of the basin is 118 m^3 and the reaction time is 180 seconds.

The Flocculation Stage:

It is the second step in purifying the river water which is held in the basin is of flocculation which is round basin contains inanimate to increase the surface area of the basin. It is of reinforced concrete column which is medley to bearing the Drawbridge Special with sweeping. Turbid water is mixed with aluminum at the bottom of the basin, then the water goes into the sintering after a period of time estimated by (20-30) minutes and then to the sedimentation basins with the period between (2-3) hours. The time duration that the water remains in sedimentation basin is 3 hours.

The sediments (Sludge), which are collected from the bottom of the basin and are removed by sweeping the tripartite arms (Scraper) continued to rake hole clarifiers in the main station in the middle of the project, where there are 5 pumps are purifying West Water Pumps (WWP) where the rotation of these pumps operate automatically as a way to dispose the waste water when the level rises after the arrival of the sedimentation basins. The total energy of the sedimentation basin is 4687 m^3/hour and the energy of each basin is 2343 m^3 /hour, a period of slow mixing is 20 minutes.

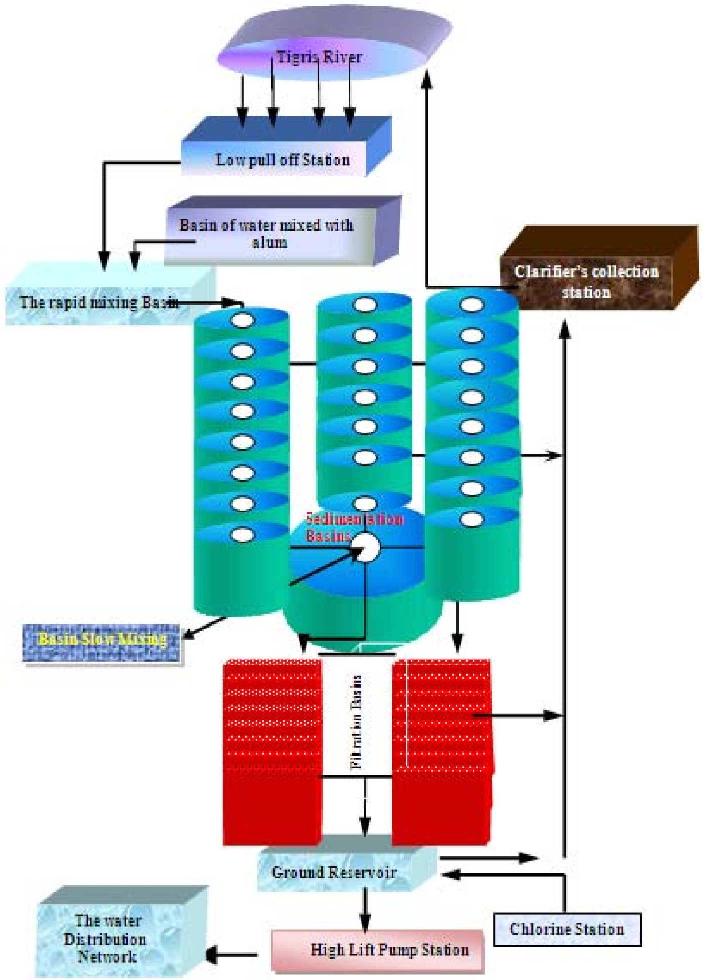

Fig. 2: Sketch the line of drinking_water treatment (DWT) plants in the project Al-Krama.

Disinfection Stage:

Water treatment process is done by adding a small amount of chloride. Disinfections method is used to kill bacteria or microorganisms in the water. Sedimentation is the tendency for particles in suspension to settle out of the fluid in which they are entrained and make it more settled. This is due to their motion through the fluid in response to the forces acting on them: these forces represented by gravity, centrifugal acceleration or electromagnetism. In Filtration stage, the water passes through filters which are made from layers of sand, gravel, and charcoal to remove smaller particles. Flocculation removes the dirt and other particles suspended in water. Aluminum and other chemicals are added to the water to form tiny sticky particles called "floc" which attracts the dirt particles. The combined weight of the dirt and the aluminum (floc) become heavy enough to sink to the bottom of basin during sedimentation (Wilczak *et al*., 1992).

Experimental Analytical:

Rates of removal between the efficiency of sedimentation and efficiency filtration basins of the plant were evaluated through the calculation of the percentage removal according to the following equation (Wiesner *et al*., 1989)

Removal Efficiency = (Turbidity inside - Turbidity outside)/Turbidity inside×100% (1)

RESULTS AND DISCUSSION

The Sedimentation Basin:

Result for removal percent of the sedimentation basin from 2005 to 2007 is indicated in Table 1. It is demonstrated that the water turbidity before sedimentation fell in range (20-15) NTU. The water turbidity of after sedimentation fell in range between (16-10) NTU. The removal efficiency of sedimentation basin varied from 32.6% to 19.0%.

Table 1: Results of the Sedimentation Basin.

Removal efficiency%	After sedimentation			Before sedimentation			
	pH	Temperature C^0	Turbidity ^{NTU}	pH	Temperature C^0	Turbidity ^{NTU}	date
48.42	7.5	19	12.04	7.3	19	17.87	3/12/2005
39.59	8.2	18	10.81	8.1	18	15.09	9/12/2005
23.48	8.3	13	16.95	8.1	13	20.93	16/12/2005
43.91	8.4	11	11.0	8.6	11	15.83	27/12/2005
30.11	7.7	10	13.32	7.5	10	17.33	2/1/2006
24.21	7.8	10	13.96	7.7	10	17.34	7/1/2006
27.40	7.6	11	14.56	8.7	10	18.55	14/1/2006
23.89	8.2	13	16.49	9.0	13	20.43	21/1/2006
35.35	8.0	11	14.37	8.6	12	19.45	30/1/2006
30.33	8.2	14	13.22	8.1	12	17.23	4/2/2007
35.32	8.6	11	14.44	8.8	11	19.54	11/2/2007
38.95	8.2	10	12.76	8.4	10	17.73	18/2/2007

Relationship between removal rate and the study period is indicated in Fig. 3. It is noted that the removal rate was decreased during the study period; hence it is an indicator to the drinking water treatment plant deficiency. It may be attributed to the following reasons:

1. Residence time in the sedimentation basin (3 hours). However, Grease Lakes Upper Mississippi River Board (MRB) recommended that the residence time of water in the sedimentation basins must be at least (4 hours) in water treatment projects (Wilczak *et al*., 1992).
2. Aluminum was added incorrectly by hand in some cases.
3. Weirs are left without cleanout for long periods of time; hence algae grew and grouped by layers.
4. The fatal circumstance that hit Iraq in the early of 2003's played an essential role in Al Karama drinking water treatment plant deterioration because of the American Army occupation to this plant and transferred it martial area.
5. The absence of workers in the laboratory of the station during the holidays resulted in a random accumulation of aluminum in the plant.

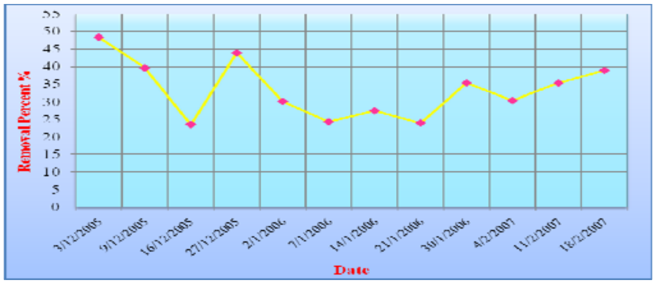

Fig. 3: Relationship between removal percent and the date of study.

The Filtration Basin:

Result for water turbidity after and before filtration from 2005 to 2007 is clarified in Table 2. Water turbidity before filtration ranged in (16.9-10.8) NTU. Water turbidity after filtration fell in rage between (13.65-3.42) NTU as given in Table 2. The removal efficiency of filtration basin varied from (93. 7%) to (70.5%). However, the removal rates of filtration basin should not be less than (90%) (Black *et al*., 1963). Therefore, result for the filtration basin efficiency and were not acceptable and it may be attributed to the fact that the presence of cracks in the walls of basin resulted in water leakage out of the basin without a filtration.

Table 2: Results of the Filtration Basin.

	After filtration			Before filtration			
Removal efficiency%	pH	Temperature C^0	Turbidity $_{NTU}$	pH	Temperature C^0	Turbidity $_{NTU}$	Date
75.9	7.4	19	2.90	7.5	19	12.04	3/12/2005
88.25	8.1	18	1.27	8.2	18	10.81	10/12/2005
92.40	8.2	18	1.15	8.3	13	16.95	17/12/2005
70.5	8.3	13	3.24	8.4	11	11.0	24/12/2005
93.7	7.6	11	0.84	7.7	10	13.32	1/1/2005
83.3	7.4	10	2.33	7.8	10	13.96	7/1/2006
82.2	7.7	10	2.21	7.9	11	12.98	14/1/2006
89.2	8.0	11	1.25	8.2	14	11.81	21/1/2006
92.0	8.2	13	1.35	8.3	13	16.93	30/1/2006
87.9	7.8	13	1.21	8.1	14	10.0	4/2/2007
91.68	8.1	12	1.33	8.2	13	16.0	11/2/2007
90.1	7.9	12	1.77	7.9	12	18	18/2/2007

Relationship between removal rate of the filtration basin and the study period is indicated in Fig. 4 it is observed that the data are oscillating during the study period.

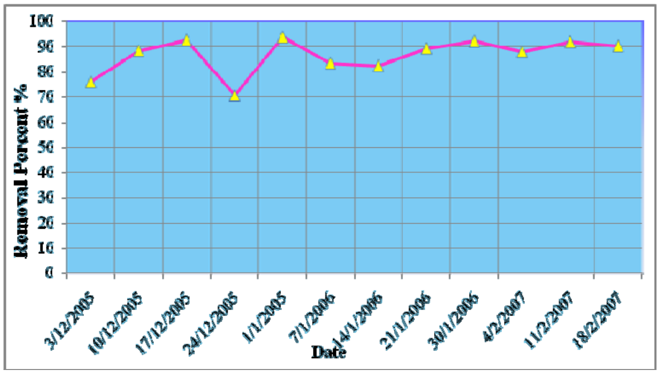

Fig. 4: Relationship between removal of the filtration basin and the study period.

PH values do not have a significant impact on water properties (Chambers *et al*., 1995). Relationship between PH and the study period is illustrated in Fig 5.

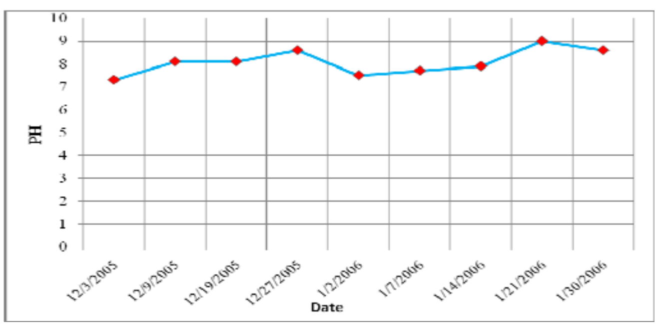

Fig. 5: Relationship between PH and the study period.

Water temperature is directly proportionate with the temperature of the atmosphere. However, water temperature does not have a negative effect on the properties of water as included in Fig 6.

Chloride content ranged in (1.7-1) ppm and it fall within the acceptable limits of the Iraqis Standards (Ali *et al*., 1993). It was indicated that chloride content increased in the rainy season due to the brownish and contaminants existence during this season as given in Fig.7.

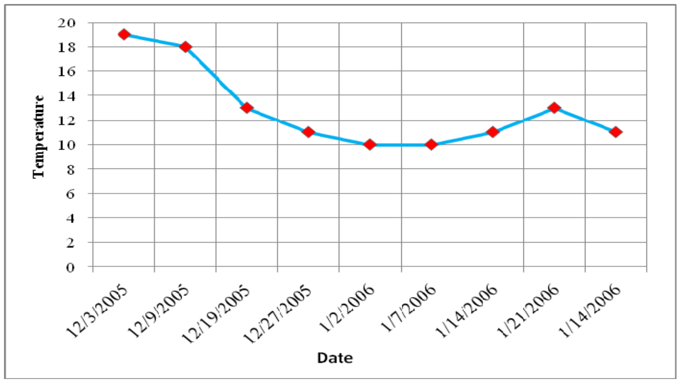

Fig. 6: Relationship between temperature and the study period.

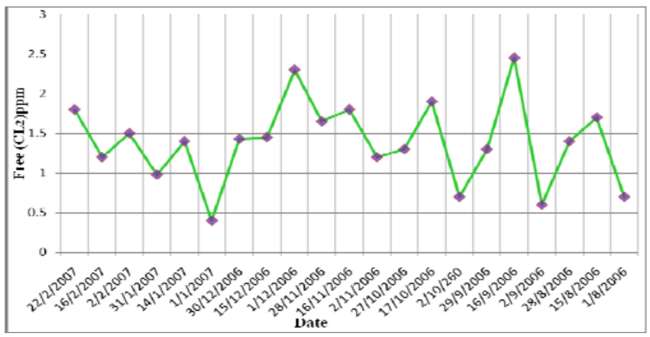

Fig. 7: Change Free (CL_2) with date during the study period.

Conclusion:

Following conclusions can be drawn based on the investigation was done on Al karama drinking water treatment plant during the study period (2005-2007):

1. The removal efficiency of the sedimentation basin varied from 32.6% to 19.0% and it was decreased during the study period.
2. The removal efficiency of the filtration basin ranged in (93. 7-70.5)% and it was decreased during the study period and didn't fit the regulations
3. Temperature is strongly influenced by the temperature of atmosphere. However, it didn't effect on the property of water. Chloride content increased during the rainy season.

Permanent maintenance to the basins plant should be provided in order to enhance the performance of the plant as well as cleaning of the basins, weirs and walls should be done continuously on an ongoing basis. Moreover, water mixing with aluminum should be done by using modern tools and spare parts to determine the amount of aluminum added in minutes. Calibration of the chemical feeding pump should be provided to specify the amount of aluminum added to water, whereby contributing to the plant durability and sustainability achievement.

ACKNOWLEDGMENTS

The authors thank the staff of Al-Krama water project for permission to collect samples of its facilities and cooperation with all aspects of this and related studies under way.

REFERENCES

Ali, A.H., 1993. A Statistical Study on Some Effects of the Aggressive War upon the Quality of Water in the City of Baghdad, M.Sc.Thesis, Build & Cons. Dep., University of Technology, Iraq.

Allayla, M.A., M.S. Hassan and N.K. Bashi, 1985. Mathemmatical Model for Turbidity Removal, Proc. of Iraq Conf. on Engineering, Iraq.

Al-Obaidi, A.H., 2005. Aluminum Concentrations in Baghdad Water Supplies, M.Sc. Thesis, Build & Cons., University of Technology, Iraq.

Al-Qaisi, R.J.K., 2005. Residual Chlorine concentrations in Baghdad water Supplies, M.Sc. Thesis, Build & Cons. Dep., University of Technology, Iraq.

Amirtharajah, A. and D.P. Wetstein, 1980. Initial Degradation of Effluent Quality during Filtration, J. AWWA, 72: 518.

Amirtharajah, A., 1988. Some Theoretical and Conceptual Views of Filtration, J. AWWA, 80(12): 36-46.

Amirtharajah, A., 1989. The Interface between Filtration and Backwashing, J. water Resources, 19: 581.

Black, A.P. and D.G. Willems, 1961. Electrophoretic Studies of Coagulation for Removal of Organic Color, J. AWWA, 53:589.

Black, A.P. and R.F. Christman, 1963. Characteristics of Colored Surface Waters, J. AWWA, 55: 753.

Chambers, V.K., J.D. Creasey, J. S. Joy, 1995. Modelling Free and Total Chlorine Decay in Potable Water Distribution Systems, Journal of Water Supply Research and Technology-Aqua, 44(2): 60-69.

Kavanaugh, M.C., C.H. Tate, R.R. Trusell and G. Treweek, 1980. Use of Particle Size Distribution Measurements for Selection and Control of Solid/Liquid Separation Processes, Particulates in Water, Characterization, Fate, Effects and Removal, Advances in Chemistry Series. American Chemical Society, Washington D.C., 189.

Kawamura, S., 1976. Considerations on Improving Flocculation, J.AWWA, 68: 328-336.

Logsdon, G.S., 1987. Evaluating Treatment Plants for Particulate Contaminant Removal, J.AWWA, 79: 82-92.

Rooks, J.J., 1974. Formation of Haloforms during Chlorination of Natural Waters, Water Treatment and Examination, 23: 234-243.

Se´rodes, J.B., M.J. Rodriguez, 1996. Predicting residual chlorine evolution in storage tanks within distribution systems, Application of a neural-network approach. Journal of Water Supply Research and Technology-Aqua, 45(2): 57-66.

Viessman, Warren and J.H. Mark, 2005. Water Supply and Pollution Control. Upper Saddle River, NJ, prentice Hall.

Wiesner, R.M. and P.P. Masounie, 1989. Raw Water Characteristics and the Selection of Treatment Configuration for Particle Removal, J. AWWA, 81: 80-89.

Wilczak, A., E.W. Howe, M. Aieta and R.J. Lee, 1992. How Pre-oxidation Affects Particle Removal During Clarification and Filtration, J. AWWA, 84: 85-94.