Water Conservation & Management (WCM)

DOI: http://doi.org/10.26480/wcm.02.2022.95.98

ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2523-5664 (Print)
ISSN: 2523-5672 (Online)
CODEN: WCMABD

CrossMark

RESEARCH ARTICLE

MANAGEMENT OF WATER QUALITY IN SOME DIALYSIS CENTRES IN GIZA GOVERNORATE HOSPITALS, EGYPT

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ARTICLE DETAILS

Article History:

Received 25 July 2022
Accepted 29 August 2022
Available online 01 September 2022

ABSTRACT

Dialysis patients are exposed to more than 40 times more water per week than healthy individuals drink. Therefore, this study aims at how to prevent risk factors that may be in the dialysis water by water quality monitoring to develop a Dialysis Water Safety Plan (DWSP) appropriate for the water source quality and conditions of each dialysis unit to prevent morbidity and mortality associated with dialysis water contaminants.

204 samples were taken from hospitals drinking water before treatment and 342 samples after treatment from 24 dialysis units from 17 hospitals that are fed from surface or underground sources in Giza from April 2020 to March 2021 monthly. Chemical and microbiological analysis were performed according to the American standard methods for the examination of water and wastewater. Visiting the treatment units once a month to monitor any change or inefficiency in any part of the unit. The findings showed that drinking water results were applicable to Egyptian limits except 2.45% for ammonia, iron (9.3%), manganese (6.86%), *Total Coliform* (2.9%), *Escherichia coli* (1.96%) and heterotrophic plate count in 1.96%. Hemodialysis water were not applicable for residual chlorine (0.87%), ammonia (1.46%), nitrites (2.6%), sodium(0.58%), potassium (0.29%), calcium (2.05%), magnesium (1.46%), total dissolved solids (1.46%), aluminium (0.58%). Total Coliform (2.6%), and E.coli in (1.46%), *Pseudomonas* (5.3%) and *Streptococcus* in (2.6%), and heterotrophic plate count (4.1%). But after the corrective actions according to DWSP, all samples became applicable. Thus, it is clear that DWSP should be implemented by developing an understanding of the system and its ability to provide safe dialysis water

KEYWORDS

Hemodialysis, Drinking Water, Chemical, Microbiological

1. INTRODUCTION

Chronic kidney disease (CKD) is a growing, global public health priority that is associated with markedly high morbidity, mortality and excess health-care costs. In 2017, CKD resulted in 1.2 million deaths and was the 12th leading cause of death worldwide (Carney, E. F., 2020). Hemodialysis is the commonest form of kidney replacement therapy in the world (Aminu K. Bello, 2022). So, dialysis water must be strictly monitored to avoid transfer harmful elements to the patient. Patients undergoing hemodialysis 'three times per week' can be exposed to 300–600 l of water depending on their prescription (Ward RA., 2011). Water resources in Giza are characterized by diversity. The water source for 15 hospitals was surface water, for two hospitals was Underground water source. By adopting an integrated plan for the hemodialysis water based on water source and its quality, we can overcome any problem related to the water, to minimize patient exposure to potential contaminants of dialysis water. A series of purification processes such as deionization, carbon filtration and reverse osmosis (RO) as shown in figure 1 are generally used to remove chemical pollutants from water and an effective barrier against microbiological contaminants (Bolasco P. et al., 2012).

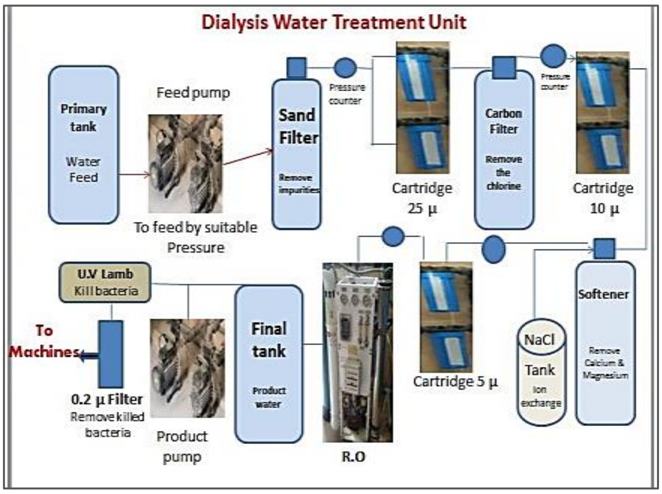

Figure1: Installation of a water treatment unit used in hemodialysis

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This study examined how to prevent risk factors that may be in dialysis water. Where each chemical produces a specific reaction; for example, sulfate (>200 mg/l) lead to nausea, vomiting, and metabolic acidosis. Adverse events have been reported in hemodialysis patients due to exposure to certain toxic chemicals aluminum, fluoride, chloramine, sulfur, and nitrate as water treatment fails (Angela D, 2013; Selenic D. et al 2004).

The main aim of the DWSP is the protection Hemodialysis patients from risks of chemical and microbiological water contaminants.

The United Nations sustainable development goals aim to reduce premature mortality from non-communicable diseases by one third by 2030. So, implementation of the Dialysis Water Safety Plan (DWSP) in all units will be an important consideration for reaching these goals.

The plan should reflect all the activities that will be undertaken, including small

Ones that can be undertaken straight away and larger ones that are identified as

Important, even though the required resources may not be immediately available.

Priority should be given to the highest-risk problems (WASH FIT, 2022).

2. Methods

All items are analysed according to Standard Methods for the Examination of Water and Wastewater (APHA, 2017).

Giza hospitals have pipe water supply system. This piped distributed in network connection used for drinking and other medical uses.

From April 2020 to March 2021, samples of water from drinking water before treatment and dialysis water after treatment collected from 17 hospitals monthly with antiseptic precautions. 204 samples of drinking water were collected before treatment and 342 samples were collected after treatment from 24 dialysis units in these hospitals.

2.1 Microbiological Analysis

The samples for microbiological testing were collected aseptically in sterile glassware. The sampling port should be sterilized with alcohol immediately before sampling. To estimate the number of *Total coliform, E. Coli, Pseudomonas aeruginosa, Streptococcus faecalis, heterotrophic plate count* (HPC) at 35 °c and 22°c (Morin P, 2000; Pedro Norton, 2017).

2.2 Chemical Analysis

Residual free chlorine was measured in the field during the sampling. The rest chemical parameters were (chloramine, ammonia, nitrite, nitrate, fluoride, sulphate, sodium, potassium, calcium, magnesium, total dissolved solids, aluminium, Barium, cadmium, chromium, copper, iron, manganese, lead, selenium, zinc and arsenic) were measured in comparison to Egyptian limits for drinking water and dialysis water.

2.3 Field Visits to Hemodialysis Water Treatment Units

Visiting the treatment units once a month to monitor any change or inefficiency in any part of the unit which consists of a sand filter, a carbon filter, a softener filter, a reverse osmosis (R.O) membranes, and finally a ultraviolet lamp (U.V) and a 0.2 micron bacterial filter to Identify potential sources of pollution and how they can be controlled.

Review operational monitoring system that ensures rapid detection of any deviation for timely corrective action;

Describing actions which was taken during normal operation or incident conditions and work on documenting it.

2.4 Statistical Analysis

Statistical analysis was done by excel sheets software, version 2013. The arithmetic mean and standard deviation were calculated for all chemical parameters, and the percentage of samples that did not applicable microbiologically.

3. Results

All chemical and microbiological test performed in triplicate. The results expressed as the mean value ± standard deviation.

3.1 Drinking Water

3.1.1 Chemical analysis

Among the 204 drinking water samples from 17 hospitals, the chemical parameters were not applicable to national standards for drinking water in five samples during study period for ammonia (2.45%), in 19 samples for iron (9.3%), in 14 samples for manganese (6.86%).

3.1.2 Microbiological analysis

The microbiological results during study period were in accordance national standards for drinking water except six samples out of 204 samples for Total *Coliform* (2.9%), four samples for *E.Coli* (1.96%) and four samples for heterotrophic plate count (1.96%) during the study period.

3.2 Hemodialysis Water

3.2.1 Chemical analysis

Among the 342 hemodialysis water samples from 24 hemodialysis units, three samples was not applicable for residual chlorine (0.87%), ammonia in five samples (1.46%), nitrites in nine samples (2.6%), sodium in two samples (0.58%), potassium in one sample (0.29%), calcium in four samples (2.05%), magnesium in five samples (1.46%), total dissolved solids in five samples (1.46%) and aluminium in two samples (0.58%).

Mean values for chemical parameters in the studied dialysis water in comparison to Egyptian limits, showed in table 1.

Table 1: Mean values of chemical parameters in the studied dialysis water in comparison to Egyptian Limits

Parameter	Egyptian Limits (Mg/l)	Mean ±SD
Aluminium	0.01	0.00147±0.004
Ammonia	Nil	0.005±0.02
Arsenic	0.005	0.00011±0.0001
Barium	0.1	0.0028±0.001
Cadmium	0.001	0.00008±0.00001
Calcium	5	0.35±0.5
Chloramine	0.1	N.D
Chromium	0.014	0.000028±0.00002
Copper	0.1	0.00256±0.002
Fluoride	0.2	0.028±0.015
Free Residual Chlorine	0.2	0.007±0.02
Iron	0.1	0.000967±0.0005
Lead	0.005	0.000039±0.00003
Magnesium	4	0.3976±0.4
Manganese	0.1	0.00121±0.0009
Nitrate	Nil	N.D
Nitrite	Nil	0.00117±0.003
Potassium	5	0.175±0.3
Selenium	0.09	0.000056±0.00005
Sodium	70	6.94±3.6
Sulphate	100	2.503±2.07
Total Dissolved Solids	200	24.17±12.7
Zinc	0.1	0.006±0.002

Mg/l, milligram per liter; SD, standard deviation

3.2.2 Microbiological analysis

As shown in Figure 2, Total *Coliform* were not applicable in nine samples (2.6%), *E.coli* was not applicable in 5 samples (1.46%), *Pseudomonas* *aeruginosa* was not applicable in 23 samples (5.3%) and *Streptococcus faecalis* was not applicable in nine samples (2.6%).

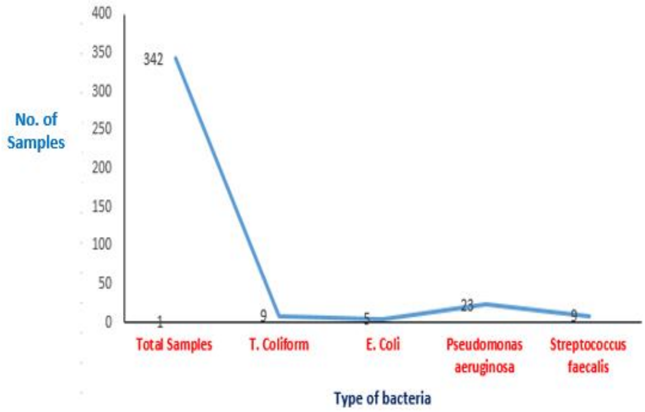

Figure 2: The number of bacteriologically not applicable samples

Also, 14 samples out of 342 samples (4.1%) higher than Egyptian limits for heterotrophic plate count during study period and table 2 shows percent of HPC Samples above Egyptian limits in the studied dialysis water units.

Table 2: Mean value for Heterotrophic plate count (HPC) results in the studied dialysis water units compared to Egyptian Limits

Parameter	Unit	Egyptian Limits	Mean ± S.D
HPC at 35^{0}C	CFU	50	7.75±8.3
HPC at 22^{0}C	CFU	50	11.64±11.1

CFU, colony-forming unit

4. Discussion

This study examined drinking water that feed 17 hospitals before entering the hemodialysis water treatment unit 204 samples and after treatment to use in hemodialysis process 342 samples from April 2020 to March 2021. There are two sources of water that feed Giza: surface water and underground water. Underground water lower in organic materials but higher in inorganic materials such as iron and manganese (Rebecca L. and Amato, 2005).

Despite this, drinking water must be treated according to the standards to get rid of the concentrations of elements that are good for a healthy individual, but at the same time, they are not suitable and may be harmful to the dialysis patient. So, Water purification system in hemodialysis centers especially, reverse osmosis leads to a sufficient decrease in the amount of contaminant parameters (Sharyari Ali et al., 2016).

The chemical results of drinking water were applicable to the national standards, except five samples of 204 that did not applicable for the height of ammonia, 19 samples for the height of iron and 14 samples for the height of manganese, because they were in hospitals fed by groundwater. However, after corrective measures were taken, these samples were re-sampled and became applicable (Minister of Health and Population Decision, 2007).

The microbiological results of drinking water were applicable to the national standards for drinking water, except for six samples of *total coliform*, four samples for *E. coli* and heterotrophic plate count. Once the water distribution system were disinfected, the results of retaking samples were applicable.

The present study revealed that dialysis water chemical parameters results of 342 hemodialysis water samples were not applicable to the national standards, for three samples due to the high residual chlorine, because the permissible concentration of chlorine in drinking water is 5 Mg/l but after treatment for hemodialysis the maximum permissible concentration is 0.2Mg/l, so after activation of the carbon filter and re-sampling of these samples became applicable. As well as ammonia in five samples and nitrite in nine samples, sodium was not applicable in two samples, potassium in one sample, calcium in four samples, magnesium and TDS in five samples, and aluminium in two samples. But after maintenance of R.O membranes and re-sampling, the samples became applicable.

The microbiological results were not applicable to national standards, for *total Coliform* in nine samples, *E.coli* in five samples, *Pseudomonas aeruginosa* in 23 samples, *Streptococcus faecalis* were not applicable in nine samples, also, 14 samples higher than Egyptian limits for heterotrophic plate count, But after sterilization of the dialysis units and changing the bacterial filter all samples were applicable.

These results have agreed with chemical results of study done on water used in dialysis centers of five hospitals in Isfahan, central Iran (Sharyari Ali et al., 2016).

The microbiological result in Greece study were the most commonly isolated bacteria

Pseudomonas spp found in 22.2% of treated water but in this study pseudomonas spp found in 5.3% and after after disinfection of water storage tanks, softeners and carbon filters within the water treatment system, all samples became applicable (Arvanitidou M. et al., 19981).

Also, the study done in Nigeria which was E. coli the commonest organism isolated in treated water in all the centers, did not agreed with microbial results of our study, where the least isolates were recorded in our study (Braimoh RW. et al., 2014).

These results have did not agreed with previous study on the bacteriological quality of dialysis water in hemodialysis unit of a tertiary care hospital in 2015, it showed that thirty-six samples of treated water analysed for bacteriological contamination. 4 out of 36 (11.1%) samples of treated water showed unacceptable bacteriological growth (Verma S. et al., 2015). But this study recorded heterotrophic plate count (4.1%).

5. Conclusion

In the end we conclude that drinking water in all hospitals under study applicable chemically to the Egyptian limits, except for some samples due to the highest of ammonia, iron but at the same time they applicable according to the World Health Organization guidelines, as no health-based guideline value for them (Guidelines for Drinking-water Quality, 2017).

The microbiological results of drinking water were applicable to the national standards, with the exception of low numbers of samples, and immediately after disinfection of the the distribution system, they became applicable.

The results of the dialysis water samples were applicable except for very limited samples, but after disinfection of water storage tanks, softeners and carbon filters within the water treatment system and changing the 0.2 micron bacterial filter, all samples applicable (Health and Safety Executive Legionnaires disease, 2013; BS, 2015).

Thus, it is clear that here should be awareness of the potential risks that may arise from the introduction of chemicals into the hospital water supply by hospital hemodialysis staff (dialysis water and dialysis fluid quality for haemodialysis and related therapies, 2020). To prevent the occurrence of these adverse effects, we recommend that the Dialysis Water Safety Plan (DWSP) should be implemented by developing an understanding of the system and its ability to provide safe dialysis water by:-

Identify potential sources of pollution and how they can be controlled.

Implementation of an operational monitoring system that ensures rapid detection of any deviation for timely corrective action.

Management and communication plans describing actions to be taken during normal operation or incident conditions and documenting system evaluation, including upgrade and improvement planning, monitoring and communication plans and support programs.

Basic technical training and technology transfer for dialysis management to staff of Kidney dialysis centers, which include various requirements aimed at ensuring the safe treatment of dialysis patients (HHS, 2008; Payne, G. M., and Curtis, J., 2021).

We recommend that the maintenance and monitoring plans for the water treatment plant be established using the knowledge acquired during the validation process for the water treatment system in accordance with BS EN ISO 23500: 2015: Guidance for the preparation and quality management of fluids for haemodialysis. Policies and procedures should be set up to ensure that routine maintenance and monitoring are mandatory and implemented at the earliest opportunity

References

A practical guide for improving quality of care through water, sanitation and hygiene in health care facilities WASH FIT, 2022. Second Edition.

American Public Health Association, APHA, 2017, American Water Work Association and Water Environment Federation. Standard Methods for Examination of Water and Wastewater. 23RD Edition.

Aminu K. Bello, Ikechi G. Okpechi, Mohamed A. Osman, Yeoungjee Cho, Htay Htay., 2022. Epidemiology of haemodialysis outcomes. https://doi.org/10.1038/ s41581-022-00542-7.

Angela D. Coulliette and Matthew J. Arduino., 2013. Hemodialysis and Water Quality Centers for Disease. Control and Prevention, Atlanta, Georgia (CDC). PubMed Central 26(4): Pp. 427–438.

Arvanitidou M, Spaia S, Katsinas C, Pangidis P, Constantinidis T, Katsouyannopoulos V, et al., 19981. Microbiological quality of water and dialysate in all haemodialysis centres of Greece Apr. Nephrology, dialysis, transplantation: official publication of the European Dialysis and Transplant Association-European Renal Association.;13(4):Pp. 949-54

Bolasco P, Contu A, Meloni P, Vacca D, Murtas S., 2012. The Evolution of Technological Strategies in the Prevention of Dialysis Water Pollution. Blood purification, 34(3-4), Pp. 238–245. https://doi.org/10.1159/000343127. PubMed, Google Scholar.

Braimoh RW, Mabayoje MO, Amira CO, Bello BT., 2014. Microbial quality of hemodialysis water, a survey of six centers in Lagos, Nigeria. Hemodialysis International. 4;18(1):Pp. 148-52

BS 8554:2015 Code of practice for the sampling and monitoring of hot and cold water services in buildings.

Carney, E. F., 2020. The impact of chronic kidney disease on global health. Nat. Rev. Nephrol. 16, Pp. 251

Department of Human and Health Services (HHS), Centers for Medicare and Medicaid Services. End-Stage Renal Disease Facilities. 2008. 42 CFR Parts 405, 410, 413, 414, 488, and 494.

Guideline on water treatment systems, dialysis water and dialysis fluid quality for haemodialysis and related therapies. 2020. Clinical Practice Guideline Prepared on behalf of The Renal Association and The Association of Renal Technologists.

Guidelines for Drinking-water Quality., 2017. World Health Organization. fourth edition incorporating the first addendum. ISBN 978-92-4-154995-0

Health and Safety Executive Legionnaires disease Part 2. The control of legionella bacteria in hot and cold water systems http://www.hse.gov.uk/pubns/priced/hsg274part

Health and Safety Executive Legionnaires disease Part 3. The control of legionella bacteria in other risk systems http://www.hse.gov.uk/pubns/priced/hsg274part3.pdf

Minister of Health and Population Decision No. 458., 2007. Standards that must be met in drinking water and human uses. The Egyptian Ministry of Health and Population.

Morin P., 2000. Identification of the bacteriological contamination of a water treatment line used for haemodialysis and its disinfection. The Journal of hospital infection, 45(3), Pp. 218–224. https://doi.org/10.1053/jhin.2000.0732

Payne, G. M., and Curtis, J., 2021. Water Treatment for Hemodialysis: Keeping Patients Safe. Nephrology nursing journal: journal of the American Nephrology Nurses' Association, 48(4), Pp. 315–345.

Pedro Norton, Joana Amaro, Natália Martins and Manuela Vieira da Silva., 2017. Water quality supply in a Portuguese teaching hospital, monitoring and studies on detection of critical points. Toxicological and Environmental Chemistry 99:1, Pp. 171 180, DOI: 10.1080/02772248.2016.1164423

Rebecca L. Amato., 2005. Water Treatment Hemodialysis updated the Latest AAMI Standards for Dialysate. American nephorology nurses journal Vol.32.No.2

Selenic D, Alvarado-Ramy F, Arduino M, Holt S, Cardinali F, Blount B, Jarrett J, Smith F, Altman N, Stahl C, Panlilio A, Pearson M and Tokars J., 2004. Epidemic parenteral exposure to volatile sulfur-containing compounds at a Hemodialysis center. infection control and hospital epidemiology Journal 25:Pp. 256–261.

Sharyari Ali, Nikaeen Mahnaz, Hatamzadeh Maryam, Dastjerdi V. Marzieh and Hassanzadeh Akbar., 2016. Evaluation of Bacteriological and Chemical Quality of Dialysis Water and Fluid in Isfahan, Central Iran. Iran Public Health Journal, Vol. 45, No.5, Pp. 650-656

Verma S, Indumathi VA, Gurudev KC, Naik SA., 2015. Bacteriological quality of treated water and dialysate in haemodialysis unit of a tertiary care hospital. Journal of clinical and diagnostic research: JCDR.9(10).DC14

Ward RA., 2011. Avoiding toxicity from water-borne contaminants in hemodialysis: new challenges in an era of increased demand for water. Adv Chronic Kidney Dis, 18:Pp. 207–213. PubMed: 2153132.