Learning Package

Health
Hunter New England
Local Health District

Renal: Water Treatment For Haemodialysis Units

Sites where Learning package applies	Clinical areas where care is provided to patients with Kidney disease requiring haemodialysis.
Description	This learning package provides an overview of water treatment for haemodialysis
Target audience	Enrolled Nurses & Registered Nurses working in the area of nephrology nursing.
Learning Outcomes, On completion of this package you will be better able to:	• Identify different sources of water and types of contaminates. • Discuss clinical manifestations of exposure to improperly treated water and dialysate. • Identify the components of water treatment system for haemodialysis and the functionality of each device. • Describe the required monitoring of the water treatment system and dialysate.

Keywords	Water, Haemodialysis, Dialysate, Contaminates
Document registration number	TBA
Replaces existing document?	Yes

Related Legislation, Australian Standard, NSW Ministry of Health Policy Directive or Guideline, National Safety and Quality Health Service Standard (NSQHSS) and/or other, HNE Health Document, Professional Guideline, Code of Practice or Ethics:

- Infection Prevention and Control Policy [PD2017_013]
- Renal Guidelines and Procedures http://ppg.hne.health.nsw.gov.au/
- NSW Renal Services Network, 2016, Water for Dialysis- A guide for In-centre, Satellite and Haemodialysis in NSW

My Health Learning code	Renal: Water Treatment for Haemodialysis (168553637)
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Issue date	
Review date	Up to three years

Renal: Water Treatment for Haemodialysis

Learning Package

2017

NSW GOVERNMENT Health
Hunter New England Local Health District

Learning Package Overview

Purpose: This package is designed to provide baseline information and to guide staff through the resources on water treatment for haemodialysis. It will be useful for both Enrolled Nurses and Registered Nurses beginning to work in the area of nephrology nursing as well as those who would like to revise their knowledge on the subject.

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Table of Contents **Page**

Introduction

This learning package is one of a suite of packages aimed at offering guided learning for nephrology nurses to further enhance their clinical skills and knowledge. The learning package on water treatment explores water sources for haemodialysis patients and units; types of water contaminates; reasons for treating haemodialysis water and water treatment systems used for haemodialysis units within Hunter New England Local Health District.

Disclaimer

This learning package has been prepared by health professionals employed in Hunter New England Local Health District in the Renal Services. While all care has been taken to ensure that the information is accurate at the time of development, the authors recommend that all information is thoroughly checked before use if utilised by another unit, context or organisation.

Naming Convention

Renal: Water Treatment for Haemodialysis Units

Aim

To enhance the knowledge of nephrology clinical staff in water treatment for the provision of haemodialysis.

Learning Outcomes or Learning Objectives

Completion of this learning package will enable the learner to:

- *Identify different sources of water and types of contaminates.*
- *Discuss clinical manifestations of exposure to improperly treated water and dialysate.*
- *Identify the components of water treatment system for haemodialysis and the functionality of each device.*
- *Describe the required monitoring of the water treatment system and dialysate.*

Pre-requisites

There are no formal prior learning requirements needed to undertake this learning package. It is however, advised that staff members who undertake this package have a minimum level of understanding in nephrology nursing that can be obtained through one of the following:

- Introduction to Nephrology Study Day
- At least two months nephrology clinical experience
- Completion of Renal Anatomy, Physiology & Pathophysiology learning package

For those people with a NSW Health employee number successful completion and submission of the learning package will be documented on My Health Learning

Learning Package Outline

The package is designed to be a self-directed learning experience that will guide you through the literature and clinical issues related to water treatment for haemodialysis.

Problem based learning

This program is based on a problem-based approach to learning. This approach has been chosen to enhance critical thinking, and to create a body of knowledge that the learner can apply to practice.

The package is developed with an adult learning framework so not all activities need to be documented but it is expected that you will complete them to facilitate your learning.

Instructions for participants

- It is estimated it will take an average of 4 hours to complete this package.
- Completion of this package is equivalent to Continuing Professional Development (CPD) hours which is a requirement for National Registration. Evidence of CPD can be generated using the reflection on learning page at the end of the package.
- Self-directed learning will be required to complete this package. Some activities will include essential reading and others will have additional supplementary readings that participants can undertake to further consolidate their knowledge.
- A brief outline of the topic followed by recommended readings & learning activities that will reinforce key points guide participants study.
- There is a suggested reference list but it is by no means complete. Please read widely to facilitate your learning. Journal articles can be accessed through CIAP. The online readings are not provided within this document due to copyright law restrictions. If you have any difficulty locating the readings please seek assistance from your relevant NE/CNE/CNS/CNC or hospital library.

This SDLP uses the following icons:

	**READING** **This icon alerts you to undertake reading related to the topic this may include Guidelines and Procedures, Journal Articles or Books**
	**LEARNING ACTIVITY** **This icon denotes a learning activity that you will need to complete**
	**GUIDELINES** **This icon alerts you to the presence of a guideline related to the subject**

Assessment process
When completed, you can return the package to relevant NE/CNE/CNS/CNC who will discuss the answers with you and provide constructive feedback. Successful completion of the package will be entered on My Health Learning.

Reflection tool
At the completion of the Learning Package we have added a reflection form that will assist you in reflecting on the package and how it meets your professional development needs.

Evaluation
A form is included at the end of the learning package for your completion. All feedback is appreciated and assists in development of a quality program. Please return the completed evaluation form to your relevant NE/CNE/CNC.

Water Supply and Contaminants

- *Identify different sources of water and types of contaminates.*
- *Discuss clinical manifestations of exposure to improperly treated water and dialysate.*

There are two main sources of municipal water supplied to the haemodialysis units, hospitals and dialysis patients' homes: Surface water and ground water. Surface water comes from places such as dams, rivers and lakes and is generally more contaminated with organisms and microbes, chemicals, fertilizers and sewage compared with ground water. Ground water comes from underground sources such as wells and springs and has lower organic material but contains higher inorganic material, such as iron, sodium, magnesium and sulphates (Layman-Amato, Curtis & Payne, 2013).

To make the water potable, water authorities often add chemicals to purify and make water healthier for consumers. Chemicals such as chlorine and chloramines are often added for disinfection; aluminium for water clarity and fluoride to provide dental care. Even though these chemicals meet the standards for drinking water, they can be toxic to haemodialysis patients (Hoenich & Ward, 2016). More extensive water treatment for haemodialysis patients is required due to the repeated exposure to large volumes of water. Depending on a patients prescription (dialysis 3 x weekly) this can be as much as 300-600L/week (Coulliette & Arduino, 2013). There is also potential for blood contamination across a dialysers semi permeable membrane and as dialysis patients don't have functioning kidneys they are unable to excrete any contaminants absorbed (Hoenich & Ward, 2016, Layman-Amato et al., 2013).

Different water contaminants can cause different effects on the patient; some can also cause damage to the water treatment plant itself. Aluminium toxicity of a dialysis patient is demonstrated by accumulation mainly in the skeleton & brain. It has been linked to symptoms of bone disease, anaemia & neurological disorders, including dementia. However due to modern water treatments for dialysis aluminium toxicity has become rare (Sharma, Toussaint, Pickering, Beeston, Smith & Holt, 2015). Calcium and magnesium build up affect the treatment plant causing the reverse osmosis (RO) membranes to become coated and scaled (Kasparek & Rodriguez, 2015). Other contaminates such as microbes can cause severe intra-dialytic complications like pyrogenic reactions and chronic micro-inflammation for the patient (Coulliette & Arduino, 2013). Chloramine exposure can cause haemolysis, anaemia and death (Layman-Amato et al., 2013); damage to the RO membrane (ACI Renal Network, 2016) and they are also thought to cause resistance to erythropoietin (EPO) agents.

All these contaminants can be found naturally in the water supply or can be added by water authorities during water treatment processes (Hoenich & Ward, 2016). As a dialysis nurse, it is important to know what the common water contaminants are, the effects they have on the haemodialysis patient and how they are removed during water treatment processes to ensure safe water is delivered during all facets of haemodialysis.

READING

1. Hoenich, N. & Ward, R. (2016) Contaminants in water used for hemodialysis. UpToDate Retrieved September 8, 2017 from www.uptodate.com

GUIDELINE

1. Renal: Management of Haemolysis during Haemodialysis HNELHD GandP 16_09

LEARNING ACTIVITY

Activity 1: Read the article by Hoenich, N. & Ward, R. (2016) Contaminants in water used for hemodialysis and identify at least 3 reasons why water needs to be more purified for the haemodialysis population?

Activity 2: Find out what the major source of water supply in your unit is and write down a list of contaminants that can be expected?

Activity 3: Use the list of contaminants that you have identified and write down the toxic effect of each contaminant. Use the above website to assist you with this activity. The contaminants should include:

- Substances added to water for protection of public health, such as aluminium, chloramines, fluoride and other contaminants such as Copper, Zinc and Lead.
- Bacteria and endotoxin

Activity 4: Residual chlorine testing is a requirement in the provision of haemodialysis. Discuss the importance of this practice include effects of exposure to chlorine and chloramines to haemodialysis patients

Water Treatment System

- *Identify the components of water treatment system for haemodialysis and the functionality of each device.*

There are many considerations to include when planning water treatment systems. These components are recommended to purify water; however, the actual requirements and settings depend on individual units and their water sources.

Feed water temperature control
Reverse osmosis (RO) membrane performance can be affected by water temperature. 15 to 20 ºC is the ideal temperature for RO membrane performance (Lloyd, 2016). Heat exchanges may be required to cool the feed water or a thermostatic mixing valve which mixes hot and cold water may be required to heat the feed water (ACI Renal Network, 2016).

Back flow preventer
All water treatment systems require a back-flow prevention device to prohibit the water in the pre-treatment system from flowing back to the feed water. This is to ensure the drinking water is protected from potential contaminants that may be used in the dialysis water treatment system (Layman-Amato et al, 2013).

Multimedia depth filters (Sediment filters)
Large particles such as dirt, silt and colloidal matter cause turbidity in feed water and can damage the RO membrane and the carbon and water softener systems (Layman-Amato et al, 2013). The multimedia filter removes the damaging particles (ACI Renal Network, 2016).

Water softeners
Water contains hard water elements such as calcium and magnesium that can form mineral deposits on the RO membrane, causing a decrease in the membranes performance and a reduction in product water quality. Ion exchange is the way hard water elements are removed. Softeners turn “hard” water to “soft” water by exchanging calcium and magnesium ions with sodium (Kasparek & Rodriguez, 2015). Sodium doesn’t deposit on the RO membrane so to protect the RO membrane the softener is positioned before the RO unit. This process may not be required in some units if their water source has lower levels of calcium and magnesium. To reduce the possibility of microbial growth the softener should also be placed before the carbon tanks (Layman-Amato et al, 2013).

Brine Tanks
The brine tank contains salt and water to create the super-saturated salt solution used for softener regeneration. The ACI Renal Network guideline recommends that the salt level in the brine tank be visually inspected daily and maintained as necessary. A ‘salt bridge’ which is a hard crust not in contact with the solution is a problem that can arise & impact on the function of the softener.

(Plant Room Tamworth Dialysis Unit HNE Health)

Ultraviolet Irradiation or Exposure (UV)

UV irradiation according to the ACI Renal Network guideline is used to kill bacteria. It can also reduce chlorine levels. The UV dose required for dechlorination is 15-30 times higher than for UV disinfection. (Waterprofessional 2017). To achieve this the UV lamp is positioned after the water softener and before carbon filtration as the next photo taken in the Tamworth water plant room demonstrates. The aim is to stabilise chlorine removal in conjunction with carbon filtration.

Carbon tanks

The function of carbon tanks is to remove chlorine and chloramine which are added to the municipal water for disinfection purposes. Even if chloramine is not normally present in drinking water, it can form naturally from the combination of chlorine and ammonia (decomposing vegetation), therefore, it is important to always test for total chlorine rather than just free chlorine alone (ACI Renal Network, 2016).

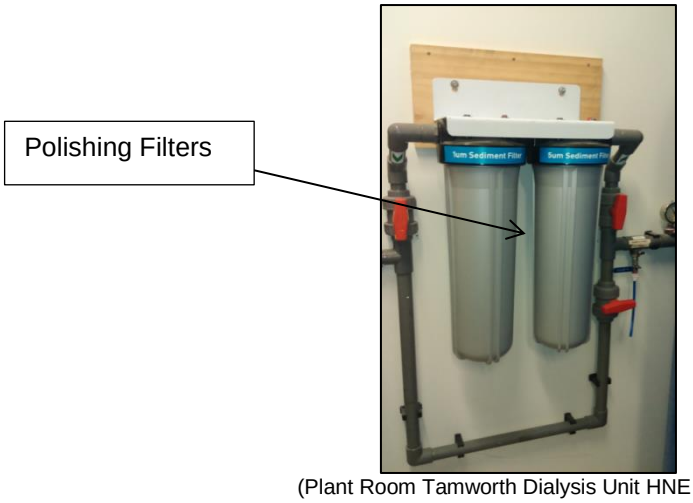
The process of both chlorine / chloramine removal is attended prior to water entering the RO system; as they are unable to be removed by the RO and can damage the thin RO membrane. The removal of chlorine and chloramine is based on contact time the elements have with the carbon contained within the tank (Layman-Amato et al, 2013). This is a critical factor in determining efficiency. Empty bed contact time (EBCT) of a minimum of 10 minutes is recommended by the ACI Renal Network.

(Plant Room Tamworth Dialysis Unit HNE Health)

Carbon tanks should be back-washed weekly at a minimum to reduce the impact of channel formation, remove debris and increase useable carbon surface. The recommendation of the ACI Renal Network water guideline is to replace carbon on a 12 monthly basis as a minimum standard of practice or earlier if high chlorine levels are experienced.

Polishing Filters

Polishing filters are positioned after the pre-treatment system, immediately before the RO pump to remove carbon fines and other debris. These filters are protection for the RO unit itself and recommendation is to replace on a monthly schedule (ACI Renal Network, 2016).



(Plant Room Tamworth Dialysis Unit HNE Health)

Reverse Osmosis System

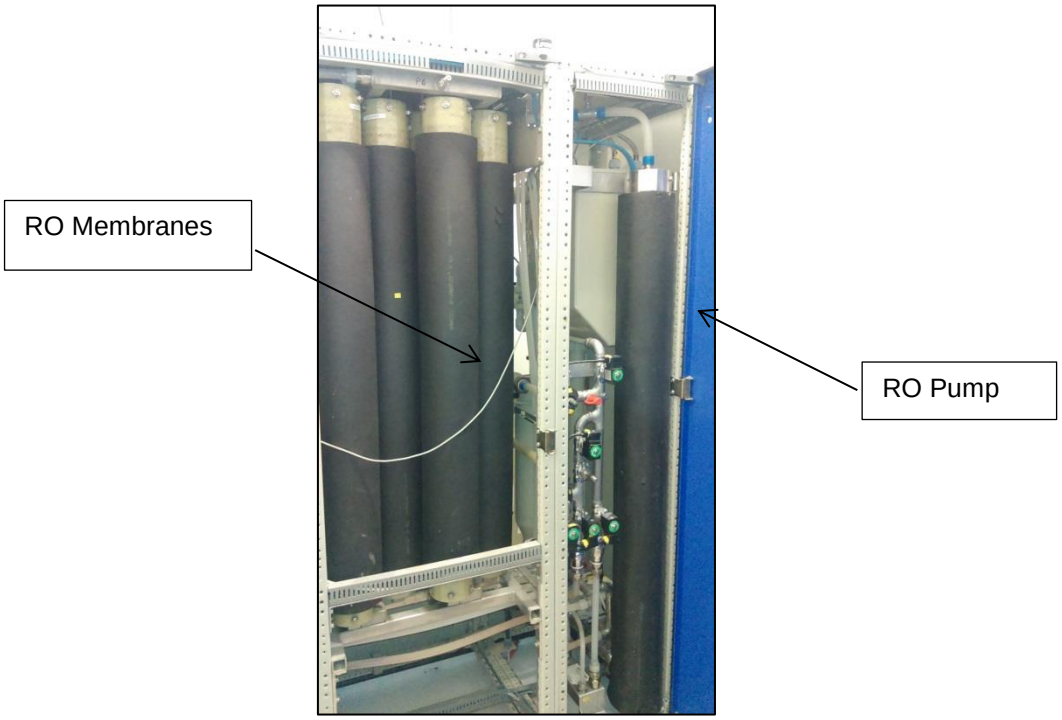
The RO system includes RO pump and RO membranes. The RO high pressure pump forces the flow of water across the RO membrane which is purposely designed with rejection characteristics for organic & inorganic contaminants to make water pure (Kasparek & Rodriguez, 2015).

The reverse osmosis membrane is a semi-permeable membrane. These membranes are commonly made of polyamide material (Hoenich & Ward, 2016). The purification process requires water to be forced under high pressure through the membrane to an area of higher solute concentration, causing unwanted contaminants to be left behind (Layman-Amato et al, 2013).

The water passed through the RO membrane is called permeate (Agar, Perkins & Heaf, 2015).This is the fluid that is supplied to haemodialysis machines for the production of dialysate. The reject product passes through a waste control system that recirculates some of the water with the remainder directed to the drainage system. The result of the RO purification process is for every 1 litre of water used by the dialysis machines at least 1 to 1.5 litres of water goes down the drain.

The RO system can be a single central system or individual units attached to each dialysis machine. This is dependent on individual unit size, environmental layout and number of machines.

(Portable RO units for ICU haemodialysis Tamworth Hospital HNE Health)



Reverse Osmosis (RO) System (Plant Room Tamworth Dialysis Unit HNE Health)

Post Treatment Components

There are some components used to further reduce the levels of bacteria that the RO alone cannot achieve, such as Ultrafilters (UF).

Submicron and Ultrafiltration (UF)

The level of bacteria in the permeate is reduced by a submicron filter however the last line of defence against potential contamination of the fluid pathway and to ensure water quality meets ISO standards are ultrafilters which remove both bacteria and endotoxins. Both submicron & ultrafilters need to be validated for medical use and are required to be disinfected or replaced regularly to prevent bacteria infestation. (Layman-Amato et al, 2013).

LEARNING ACTIVITY

Activity 5: When should a Diasafe Plus® filter be changed for a Fresenius 5008 machine?

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GUIDELINE

2. Locate the HNELHD Guideline and Procedure Renal: Changing Diasafe Plus® Filter(s) and Ultrafilters on haemodialysis Machines
3. ACI Renal Network. (2016). Water for dialysis: A guide for in-centre and satellite haemodialysis units in NSW and for home haemodialysis. Read section 2 Planning pages 17-27 Located at:

https://www.aci.health.nsw.gov.au/__data/assets/pdf_file/0007/306088/water-for-dialysis-2016.pdf

Distribution System

The distribution system can be direct or indirect. The direct system which units in HNE Health have doesn't have a storage tank and delivers permeate from the RO directly to the loop for distribution. This system is considered more robust as it limits the potential introduction of contaminants and restricts bacterial growth. The indirect system accumulates the permeate fluid into a storage tank which then delivers the fluid into the distribution loop, there are no indirect distribution systems used in HNE Health. The flow velocity which is the speed at which permeate fluid travels through the distribution loop, should be regularly evaluated and the loop disinfected by heat or chemicals routinely (ACI Renal Network, 2016)

Home Haemodialysis

The water treatment setting is different for home haemodialysis patients; it is much simpler but still includes all major components such as filters, carbon tanks and RO system. The picture below is an example of a home haemodialysis set up for home dialysis patients.

READING

2. Agar, J., Perkins, A., & Heaf, J. (2015). Home hemodialysis: Infrastructure, water, and machines in the home. Hemodialysis International, 19: 593-5111

LEARNING ACTIVITY

Activity 6: Please state the function of water softener and investigate if the haemodialysis unit in your workplace uses a water softener. If not, please state the reason why the water softener is not used.

Activity 7: Investigate how many carbon tanks are used in the haemodialysis unit in your workplace and state the reasons why 2 carbon tanks are required.

Activity 8: What is the distribution system in your unit, and what are the disinfection methods?

Monitoring System

- *Describe the required monitoring of the water treatment system and dialysate.*

Dialysis water quality needs to be tested and monitored regularly according to the ACI Renal Network Water for dialysis guide to avoid excesses of known or suspected contaminants being transferred to haemodialysis patients. The International Organization for standardization (ISO) standards is the recognised minimum standards for water pre-treatment for haemodialysis in NSW (ACI Renal Network 2016).

Water hardness

Hardness of the water should be tested prior to the design of the water pre-treatment system to assist with the decision on whether a softener is required for the individual unit. Once the softener is installed, it is recommended to be tested at least six monthly or after a carbon tank is changed to ensure the softener is performing adequately (ACI Renal Network 2016).

Chlorine and Chloramine (total chlorine)

Chlorine and chloramine testing must be attended and recorded per dialysis shift using the manual process photometer (colorimeter) method. This method can measure total and free chlorine and should be considered as the minimum acceptable standard method for a dialysis unit. The test should occur post the RO unit (ACI Renal Network, 2016).

The maximum acceptable level of chlorine and chloramine is 0.1mg/L as recommended by ISO13959:2014 (ACI Renal Network, 2016). When trending of test results indicates an increase in the level of chlorine, or a level of ≥0.1mg/L is recorded dialysis should not proceed until the unit manager/Team Leader and/or technicians are informed and the situation investigated.

Residual Testing

Undertaken at the completion of maintenance of the water plant and on dialysis machines after disinfection has been attended using sodium hypochlorite (bleach) to ensure that there is no residual chemical left (ACI Renal Network, 2016).

LEARNING ACTIVITY

Activity 9: A dialysis treatment should **NOT** be commenced if the total chlorine result is above what level?

Activity 10: What actions should be taken if the reading is above the acceptable level?

Activity 11: What actions should be taken for a positive residual chlorine result?

GUIDELINE

4. Locate the HNELHD Guideline and Procedure Renal: Haemodialysis Machine Care, Cleaning, Disinfection and Chlorine Testing.
5. Locate the HNELHD Guideline and Procedure Renal: Water sample collection for microbiological testing of dialysate on dialysis machines.

Bacteria (CFU) & endotoxin testing

CFU is a measure of bacterial cell numbers that arise from a single cell when grown on a solid media (Fresenius Medical Care, 2013) and endotoxins are a major part of the outer cell wall of gram-negative bacteria (ACI Renal Network, 2016). According to the ACI Renal Network Water for dialysis: A guide for in-centre and satellite haemodialysis units in NSW and for home haemodialysis (2016) bacterial levels should be tested at a maximum interval of three monthly after commissioning and a validation period. The endotoxin levels should be measured every 6 months for dialysis water pre-treatment systems. The HNELHD Guideline and Procedure Renal: Water sample collection for microbiological testing of dialysate on dialysis machines provides guidance for bacteria and endotoxin testing for Fresenius 5008 machines.

LEARNING ACTIVITY

Activity 10: Complete the following table using the above guideline for the actions you would take for the stated CFU & Endotoxin levels:

CFU Results	Action Required
< 0.1 CFU/ml	
0.1 CFU/mL to <100 CFUmL	

LEARNING ACTIVITY

CFU Results	**Action Required**
>100CFU/ml	
Endotoxin Results	**Action Required**
<0.03 EU/ml	
0.03 EU/ml to 0.25 EU/ml	
>0.25 EU/ml	

References

Agar, J.W., Perkins, A., & Heaf, J.G. (2015). Home hemodialysis: Infrastructure, water, and machines in the home. *Hemodialysis International,* 19, 593-5111. Doi:10.1111/hdi.12290

Coulliette, A.D., & Arduino, M.J. (2013). Hemodialysis and Water Quality. *Seminars in Dialysis,* 26, 427-438. Doi: 10.1111/sdi, 12113

Hoenich, N. & Ward, R. (2016). Contaminants in water used for hemodialysis. *UpToDate*, Retrieved from www.uptodate.com

Hoenich, N & Ward, R. (2016). Water purification systems in hemodialysis. *UpToDate,* Retrieved from www.uptodate.com

Kasparek, T., & Rodriguez, O.E. (2015). What Medical Directors Need to Know about Dialysis Facility Water Management. *Clin J Am Soc Nephrol,* 10(6), 1061-1071. Doi: 10.2215/CJN. 11851214

Layman-Amato, R., Curtis, J., & Payne, G.M (2013) Water Treatment for Hemodialysis: An Update. *Nephrology Nursing Journal,* 40(5) 383-404.

Lloyd, J. (2016). Water – The first ingredient of the dialysis prescription. *The CANNT Journal,* 26(1)30-33

NSW Renal Services Network. (2016). *Water for Dialysis- A guide for in-centre and satellite haemodialysis units in NSW and for home haemodialysis.* Retrieved from https://www.aci.health.nsw.gov.au/__data/assets/pdf_file/0007/306088/water-for-dialysis-2016.pdf

Sharma, A.K., Toussaint, N.D., Pickering, J., Beeston, T., Smith, E.R., & Holt, S.G (2015). Assessing the utility of testing aluminum levels in dialysis patients. *Hemodialysis International,* 19, 256-262. Doi:10.1111/hdi.12231

Waterprofessionals (2017) http://www.waterprofessionals.com/learning-center/dechlorination/

Learning Package: Reflection on Learning

This document guides your reflection on the extent to which the package meets your professional development needs, and how you plan to apply your learning into practice. This tool is not part of the assessment process, and has been included as a document that you may wish to include in your professional portfolio. Time taken to complete learning package_____

What was your purpose in completing this learning package?

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Did you achieve this by completing the learning package?

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Reflecting on the content, what key learning have you obtained?

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What learning will you apply to your practice immediately? How will you do this?

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What learning needs have you identified as a result of completing this learning package?

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How do you plan to address these needs?

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Signature:_____ Date:_____

Learning Package Evaluation Form

Your feedback regarding this learning package is important to ensure the package meets your learning needs. Please take 5 minutes to answer the following questions to facilitate any change required for future learning packages.

1. The learning outcomes of the learning package were clearly identified	Yes	No
2. The learning outcomes of the package were appropriate	Yes	No
3. The content provided enabled me to meet the learning outcomes?	Yes	No
4.The activities motivated my interest in the topic	Yes	No
5.The activities and workbook questions supported my understanding of the topic	Yes	No
6.The package was presented in a logical manner	Yes	No
7.The assessment process related to this package was clearly outlined (if applicable)	Yes	No

8. My most relevant learning outcomes from this package were:

_____

_____

9. The key learning points from this package I can immediately apply to practice include:

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10. The least relevant component(s) of this package were:

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11. Some suggestions I would like made to improve the package would be:

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12. Further comments:

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Thank you for your time to complete the evaluation
Return to:

The relevant CNE/NE/CNC within your area.