The Precision Water Systems distiller was very effective in the removal of the pathogens tested. No pathogens were detected in the distilled water. ***Table 1*** summarized these results, listing the concentrations in the initial raw water, in the finished water and removal efficiencies.

TABLE 1 Removal efficiencies and concentrations of pathogens in raw and finished waters.

Pathogen		Raw Water Conc.	Finished Water Conc.	Removal Efficiency (%)
Cryptosporidia	(cysts/10L)	3000	<1	>99.97
Giardia lambia	(cysts/10L)	3000	<1	>99.97
Total Coliforms	(cfu/100ml)	>10000	<1	>99.99
Fecal Coliforms	(cfu/100ml)	>10000	<1	>99.99

Removal efficiencies and of trace metals and the radioactive nucleotide are summarized in ***Tables 2 & 3***. ***Table 2*** shows the results for trace metals and ***Table 3*** shows the results for the radioactive nucleotide, Radium 226. Of particular note in these results are the removal efficiencies of the toxic heavy metals: lead, cadmium and mercury, of the radioactive nucleotide and of arsenic. Arsenic, cadmium and radium 226 were not detected in the finished water.

Table 2. Removal efficiencies and concentrates of trace elements in raw and finished waters.

Trace Element	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
Arsenic	0.06	<0.0004	>99
Barium	0.28	0.0005	>99
Boron	0.52	<0.002	>99
Cadmium	0.05	<0.0002	>99
Cobalt	0.06	<0.0002	>99
Iron	2.83	<0.02	>99
Lead	0.07	0.0003	>99
Mercury	0.05	0.00023	>99
Nickel	0.15	<0.0015	>99
Selenium	0.06	<0.0004	>99
Sodium	2.00	0.026	98.7
Vanadium	0.06	<0.0002	>99

Table 3. Removal efficiencies and concentrations (measured as radioactivity) of radio nucleotides in raw and finished waters.

Radio Nucleotide	Raw Water Conc. (Bq/L)	Finished Water Conc. (Bq/L)	Removal Efficiency (%)
226 Radium	3.40	<0.005	>99

The results for nutrients and common anions are shown in ***Table 4***. The water distiller effectively removed 99% or more of the chloride, nitrate and ammonia in the raw water. No fluoride and phosphate were detected in the finished water but high detection limits for these parameters only limit the demonstration of removal efficiencies greater than 90% in this study. It should be possible to achieve demonstrated removal efficiencies of greater than 99% with lower detection limits.

Table 4. Removal efficiencies and concentrations of nutrients and common anions in raw and finished waters.

Anions & Nutrients	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
Chloride	11.0	0.110	99
Nitrate (as Nitrogen)	6.40	0.060	>99
Ammonia (as Nitrogen)	1.00	<0.005	>99

Table 5 summarizes the results achieved for a selection of herbicides and insecticides. This study focused on the herbicides commonly used in Western Canada. Removal efficiencies of 99% or more were achieved for all but one of the compounds tested. The removal efficiency for Trifluralin was 98%

Table 5. Removal efficiencies and concentrations of pesticides in raw and finished waters.

Pesticides	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
Trifluralin	0.29	0.006	98
MCPA	0.50	0.0002	>99
y-BHC (Lindane)	0.59	0.0023	>99
Dicambia	0.63	0.0001	>99
2,4-D	0.48	<0.0001	>99
Bromoxynil	0.38	0.0006	>99
Triallate	0.47	0.005	99

Volatile Priority Pollutants

These are toxic compounds, which readily evaporate and include most common solvents. Most are chlorinated and/or aromatic in nature. This class of chemical is an excellent test of the water distillation system because of the inherent difficulty of removing these chemicals from water by distillation.

The results obtained are summarized in ***Table 6.*** The water distiller effectively removed all of the volatile chemicals tested. Only chloroethane, the most volatile of the chemicals tested was removed with less than 99% efficiency.

Table 6 Removal efficiencies and concentrations of volatile priority pollutants in raw and finished waters.

Volatile Priority Pollutant	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
Benzene	1.12	<0.001	>99
Bromoform	1.50	0.005	>99
Carbon tetrachloride	0.64	<0.001	>99
Chlorobenzene	0.44	<0.001	>99
Chloroform	0.75	0.005	>99
Chloromethane	0.66	<0.01	>99
1,3-Dichlorobenzene	0.68	<0.001	>99
1,1-Dichloroethane	0.54	0.004	>99
1,2-Dichloroethane	0.66	0.01	99
Trans-1,2-Dichloroethene	0.48	<0.001	>99
1,1,2,2-Tetrachloroethane	1.70	<0.020	>99
Tetrachloroethene	0.70	<0.001	>99
Toluene	3.95	<0.001	>99
Trichloroethene	0.91	<0.001	>99
p-Xylene	0.35	<0.001	>99
MTBE	0.86	0.0023	>99

Phenolic Priority Pollutants

These are toxic organic chemicals that include the phenol functional group. They are more soluble than other organic compounds and distribute quickly in aqueous systems. The results obtained for these compounds are summarized in ***Table 7.*** Of the chemicals tested, only 2-chlorophenol and 3-chlorophenol were found in the finished water and at very low, trace concentrations. None of the more toxic, polychlorinated phenols were detected in the finished water.

Table 7. Removal efficiencies and concentration of phenolic priority pollutants in raw and finished waters.

Phenolic Purity Pollutant	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
4-Chloro-3-methylphenol	0.48	<0.001	>99
2-Chlorophenol	1.10	0.002	>99
3-Chlorophenol	0.92	0.001	>99
2,4-Dichlorophenol	0.66	<0.001	>99
2-Nitrophenol	0.57	<0.002	>99
Pentachlorophenol	0.37	<0.005	>99
Phenol	0.23	<0.001	>99
2,4,6-Trechnorophenol	0.35	<0.001	>99

Base/Neutral Priority Pollutants

These are less volatile, less soluble toxic compounds associated with industrial wastes. They are more stable and persistent than the other priority pollutants discussed above. The results achieved with a selection of these chemicals are summarized in ***Table 8.*** Removal of these compounds with the water distillation system was very effective.

Table 8. Removal efficiencies and concentrations of base/neutral priority pollutants in raw and finished waters.

Base/Neutral Priority Pollutant	Raw Water Conc. (mg/L)	Finished Water Conc. (mg/L)	Removal Efficiency (%)
bis(2-Chloroethyl) ether	0.55	0.001	>99
bis (2-Chloroethoxy) methane	0.86	0.002	>99
2,6 Dinitrotoluene	0.84	<0.002	>99
Fluoranthene	0.45	0.002	>99
Hexachloroethane	0.39	<0.001	>99
Isophorone	0.85	0.002	>99
Nitrobenzene	0.73	<0.001	>99
N-nitrosodiphenylamine	0.28	<0.003	>99
Phenanthrene	0.70	0.001	>99
Biphenyl	0.82	<0.001	>99
1-Methylnaphthalene	0.43	<0.001	>99

PRECISION WATER DISTILLERS

INTRODUCTION

This study was undertaken to evaluate the effectiveness with which Precision Water Systems – Precision Pure Model: PWS 12-12 water distillation system removes harmful contaminants from water. The contaminants used in this study were selected to be representative of human pathogens found in natural waters and industrial chemicals, including pesticides.
Pathogens were Giardia lambia, Cryptosporidia and coliform bacteria (fecal and total). Chemical classes represented include: pesticides, phenolic industrial pollutants, volatile industrial pollutants, semi-volatile base/neutral industrial pollutants, trace elements, major ions and nutrients, radio nucleotides, poly-chlorinated biphenyls (PCBs) and polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs).

METHODS

The Precision Pure Model: PWS 12-12 water distillation unit was chosen for this evaluation. This unit has the highest rate of distillation in their residential line of products and therefore represents the worst-case scenario for removal of contaminants. Other Precision Water Systems distillation units should perform as well as or better than the PWS 12-12 water distillation unit.
A 40 liter (L) stainless steel reservoir, fitted with small electric feed line pump, was used to supply water to a Precision Water Systems – Precision Pure Model: PWS 12-12 water distillation unit. Contaminants were added to the water in the reservoir and mixed thoroughly before the distillation was started.
The Manitoba Technology Centre supplied giardia lambia and Cryptosporiidia cysts; coliform bacteria were supplied by the Enviro-Test Industrial Hygiene Laboratory and radium 226 was conducted at the Saskatchewan Research Council. Analysis of water samples for Giardia lambia and Cryptosporiidia was conducted at the Manitoba Technology Centre; analysis of water samples for total and fecal coliform bacteria was conducted at the Enviro-Test Industrial Hygiene Laboratory and analysis of water samples for radium 226 was conducted at the Saskatchewan Research Council. Chemicals, added as contaminants, were standards of purchased certified or reported purity.
Water samples were collected from the reservoir, before the distillation was started and from the water distiller storage tank following distillation. These samples were analyzed to determine initial and final concentrations of contaminants from which the removal efficiency was calculated.
The elimination pathogens and the removal of chemicals were evaluated in separate experiments. This was to ensure that the observed removal of pathogens was due solely to the distillation unit and not the result of chemical toxicity.
The analyses of the samples were conducted using methods described in Standard Methods for the Examination of Water and Wastewater (20th Edition) or United States Environmental Protection Agency (US-EPA) test methods. Analyses of the distilled water were conducted using the most sensitive methods available.

RESULTS

Removal efficiencies and concentrations of the contaminant in the raw and finished water (before and after distillation) are presented in Tables1-8. When, in most cases, contaminants were not detected in the finished water, the method detection limit with a "less than" sign, "<" in front of it was reported. In these cases, the demonstrated removal efficiency is better than that which would have reached the detection limit. It is reported as greater than the removal efficiency required to achieve concentrations at the contaminant detection limit in the finished water. Concentrations and removal of contaminants detected in the finished water were reported without modification. Results for chemicals tested and not found in the finished water, but with detections limits too high to demonstrate > 99% removal are not included.

CONCLUSIONS

The study shows that the Precision Water Systems Precision Pure Model: PWS 12-12 water distillation unit is a very effective water treatment system capable of removing both harmful pathogens and toxic chemicals from water. In this study, all pathogens tested were eliminated. None were found in the finished water. The water distillation system also effectively removed all of the soluble inorganic and organic chemicals tested.
Removal efficiencies of *99% or greater* were achieved for almost all of chemicals tested.

It is apparent that Precision Water Distillers are very efficient at removing:

From Table 1:	Pathogens such as cryptosporidia and Giardia lambia.
From Table 2:	Trace elements such as arsenic and lead.
From Table 3	Radio nucleotides such as 226 Radium
From Table 4:	Anions and Nutrients such as Chloride and Nitrates
From Table 5:	Pesticides
From Table 6:	Volatile Priority Pollutants
From Table 7:	Phenolic Priority Pollutants
From Table 8:	Base/Neutral Priority Pollutants

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An Evaluation of

PRECISION WATER DISTILLERS

Precision Water Systems
Precision Pure Model: PWS 12-12

for

Removing Toxic Industrial

and

Agricultural Contaminants

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A Division of ETL Chemspec Analyical Ltd.
Edmonton, Alberta
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Prepared by: Ian Johnson, Ph.D.
Senior Scientist, II

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Standards Council of Canada in Cooperation with the Canadian Association for Environmental Analytical Laboratories

(CAEAL) for Specific Tests as Registered by the Council (Edmonton, Calgary, Saskatoon, Winnipeg, Thunder Bay)

American Industrial Hygiene Association (AHA) for Industrial Hygiene analysis (Edmonton, Winnipeg)

Standards Council of Canada in cooperation with the Canadian Food Inspection Agency (CFIA) for fertilizer and feed testing (Saskatoon)