Water Quality
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture, Food and Fisheries

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TREATING IRRIGATION AND CROP WASH WATER FOR PATHOGENS

Water Quality Monitoring

Many of British Columbia's surface water supplies will contain pathogens that are a risk to human health. Septic fields, animal manure, milk house wastes, and wildlife are all sources of pathogens that can enter surface or groundwater. Many irrigation and crop wash water supplies are from agricultural drainage ditches. While ditches are often prone to poor water quality, all surface water sources may contain pathogens.

Due to the extensive diversity of microorganisms found in the aquatic environment it is expensive to identify all species for monitoring purposes. Therefore an indicator organism or surrogate organism that is easily detectable is often used to identify fecal contamination.

Figure 1 Drainage Ditch Used for Irrigation Supply

Fecal Coliforms

Fecal coliforms are used as an indicator organism as they:

- Are present when pathogens are present, absent when pathogens are absent.
- Are present in sufficient numbers to provide an estimate of pathogen density.
- Are easily and economically quantifiable and do not provide false tests.
- Respond similarly to the pathogens of interest.

The limitations of using fecal coliforms as indicators are:

- Fecal coliform tests detect both potentially harmful bacteria like *E Coli* and less harmful bacteria like *Klebsiella.* Where effluent sources are from industrial food processing or dairy farms, the effluent may show a high positive fecal coliform test without the presence of fecal matter.
- Fecal coliforms are not useful as indicators of pathogens responsible for eye, ear, nose, throat or skin infections and the presence of viruses, protozoans or worms.
- Fecal coliform indicators will not identify pathogens of non-fecal origin.
- The relative densities of viruses and fecal coliforms may have low correlation with each other.

The units for measurement are Colony Forming Units (CFU). The standard for measurement is CFU/100ml.

E. Coli

E. Coli is often used as an indicator as it is more specific to human fecal contamination than any other group of organisms. The normal standard for measurement is CFU/100ml.

Agricultural Water Quality Standards

Water quality standards for various agricultural uses in British Columbia are shown in Table 1.

Table 1 WATER QUALITY STANDARD FOR PATHOGENS

Water Use	E. coli	Fecal Coliforms
Irrigation of crops eaten raw	< 77 cfu/100ml	< 200 cfu/100 ml
Irrigation general	< 1000 cfu/100ml	< 1000 cfu/100ml
Crop Washing	0 cfu/100ml	0 cfu/100ml

Source: BC Ministry of Water, Land and Air Protection / Health Canada

If the irrigation water quality for crops eaten raw exceeds the specific standard shown above, a recommendation is to not irrigate the crop within 14 days prior to harvest. The reasoning is that over 14 days there will have been sufficient sunlight and heat to reduce the number of pathogens to a safe level.

Ultraviolet Water Treatment For Pathogens

Ultraviolet light is a part of the natural light spectrum. It is invisible to the human eye but can destroy micro-organisms like bacteria, fungi and algae. Sunlight contains ultraviolet light but in lower quantities, requiring many days for sunlight to kill pathogens.

Intensity

Ultraviolet lamps can provide much higher intensities than sunlight. For high intensity lamps the contact time for pathogen kill can be very short. The measurement of intensity is microwatt per square centimeter ($\mu w/cm^2$). The two factors that affect intensity are the output of the lamps and the water quality.

The lamp output can be maintained by cleaning the quartz sleeve every six months or so and replacing the lamps every year. Monitoring equipment can be put on the ultraviolet unit to ensure that proper lamp outputs are maintained.

Time

The exposure time to the ultraviolet light is determined by the flow rate of the water going through the unit. Increasing the flow rate decreases the exposure time and the corresponding dosage. Higher intensity lamps are then required to ensure effective treatment.

Dosage

Ultraviolet dosage is determined by multiplying the light intensity by the exposure time. Increasing the light intensity or increasing the exposure time increases the dosage. The measurement for dosage is microwatt - seconds per square centimeter ($\mu w\text{-}sec/cm^2$).

The standard to disinfect water contaminated by organisms such as bacteria and viruses is 38,000 $\mu w\text{-}sec/cm^2$. The ultraviolet dosage required to kill various organisms will vary with different species. Most species will be destroyed with the standard suggested.

For example, Table 2 provides information on the dosage required to treat salmonella and E. coli to various levels. A 99.9% reduction is sufficient in almost all instances to achieve the water quality standards in Table 1. The increased dosages to achieve 99.999% (5 log reduction) is not warranted in most instances.

Ultraviolet light also provides good protection against Giardia and Cryptosporidium, two waterborne parasites.

Table 2 ULTRAVIOLET DOSAGES TO TREAT MICRO ORGANISMS $\mu w\text{-}sec/cm^2$

Organism	Type	% Reduction		
		99.9%	99.99%	99.999%
Salmonella	Bacteria	10,000	13,333	16,666
E. coli	Bacteria	6,600	8,800	11,000

Source: International Water Guard

Water Quality

The penetration of light through water is limited by the water quality (Table 3). Water that does not have good clarity and contains high levels of suspended solids or dissolved organics will restrict light penetration. Dissolved organics are of particular concern as they have very high ultraviolet absorption capacity.

Filtration of the water is required for all surface water to ensure that adequate penetration of ultraviolet light is achieved through the entire flow profile. The transmission of light through ditch water is expected to be less than most surface water sources. It is estimated that only 50% of the ultraviolet light can be transmitted through ditch water. See Table 3.

Iron is also a problem as it can coat the quartz sleeves, reducing light intensity.

Dissolved minerals and inorganic suspended solids are usually not much of a concern. Inorganic solids should also be filtered out of the water with a sand filtration system.

Table 3 ULTRAVIOLET TRANSMISSION

Application	Transmission*
Drinking Water	90%
Surface Water	70%
Wastewater (Filtered)	60%
Ditch Water (Filtered)	50%**

Source: International Water Guard

* Expressed as a percentage of Deionized Water

** Estimated by MAFF

Ultraviolet Treatment Design Criteria

- A sand filter is required prior to the ultraviolet unit to ensure maximum transmission of the ultraviolet light through the water. See Figures 2 and 3. The sand filter must be designed not to exceed a flow rate of 15 gpm/ft^2 of bed area.

Figure 2 Sand Filter Units

- After being filtered ditch water is estimated to have a transmission level of 50%. This value may be conservative but is selected to ensure that sufficient dosages are applied.
- Turbulent flow should be achieved through the ultraviolet units. If the flow is smooth and doesn't mix then microorganisms may be able to pass from the inlet to the outlet without having sufficient contact time.
- **For crop washing facilities an ultraviolet dosage of 40,000 µw-sec/cm^2 is recommended.**
- Chlorination is required with washing facilities and should be used with care. Wash water cannot be discharged into the ditches after use if residual chlorine is present.
- **For irrigation system treatment an ultraviolet treatment of 16,000 µw-sec/cm^2 is suggested. Irrigation water treatment should be started 30 days prior to harvest.**
- The maximum pressure in the ultraviolet unit should not exceed 100 psi. Giant gun irrigation systems will therefore require a booster pump after the ultraviolet unit.

Ultraviolet Unit Sizing

The size of the ultraviolet unit will depend on the flow rate, light intensity and water quality. Table 4 provides a guide to selection of an ultraviolet system for water clarity, ultraviolet dosage, flow rate and costs. The costs are approximate and only include the costs of the sand filter and ultraviolet unit. Piping and installation costs are extra. The information in Table 4 is based on ultraviolet units from International Water Guard. Costs are estimated by H_2O Irrigation Ltd. and Watertec Irrigation Ltd.

Photo courtesy of International Water Guard

Figure 4 Ultraviolet Treatment Unit

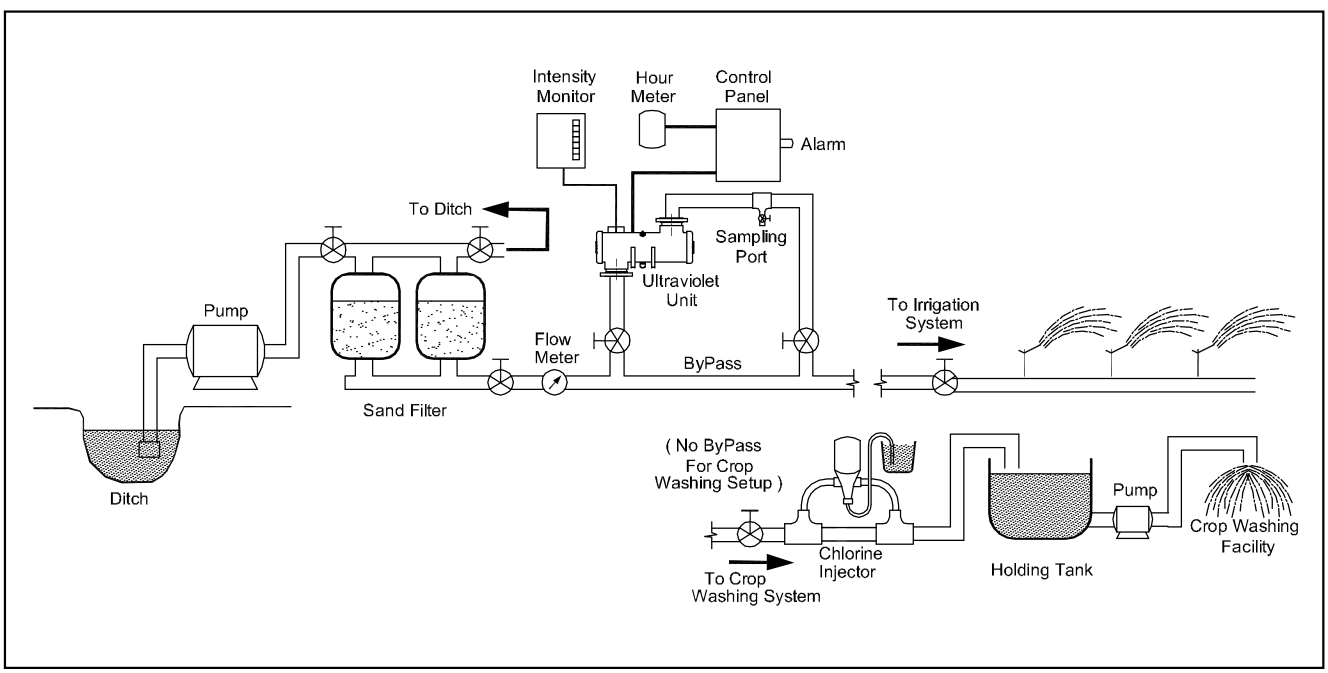

Figure 3 Schematic of Ultraviolet Treatment System

Table 4	PRODUCT SELECTION – DOSAGE IS FOR 50% WATER CLARITY		
Flow Rate	**Ultraviolet Dosage µw-sec/cm2**	**UV Chamber Only c/w intensity and hour meter**	**Complete Filter System c/w UV, valves and sand filters**
25 gpm	16,000	$2250	$7700
25 gpm	40,000	$3800	$9300
50 gpm	16,000	$3800	$12,100
50 gpm	40,000	$6600	$15,000
75 gpm	16,000	$3800	$12,300
75 gpm	40,000	$6600	$15,200
100 gpm	16,000	$6600	$17,100
100 gpm	40,000	$9400	$20,000
150 gpm	16,000	$6600	$20,200
150 gpm	40,000	$12,100	$25,700
200 gpm	16,000	$9400	$23,100
200 gpm	40,000	$18,100	$31,900
300 gpm	16,000	$12,100	$29,000
300 gpm	40,000	$23,000	$39,000
400 gpm	16,000	$18,100	$37,000
400 gpm	40,000	$32,700	$51,600
500 gpm	16,000	$18,100	$37,900
500gpm	40,000	$32,700	$52,500

Monitoring Equipment

There are a number of accessories that can be added to the ultraviolet treatment unit to ensure proper dosage is continually applied.

Intensity Monitor

This unit monitors the intensity of the ultraviolet wave length. It is located at the center rim of the disinfection chamber and will inform the operator if there is either a change in the water quality or a reduction in the lamp outputs.

Thermal Sensor

The lamps work best at a temperature of 40^{o}C. If the water temperature increases too much the lamp performance may be effected. The thermal sensor will shut the system down if the temperature exceeds a preset level.

Hour Meter

The non resettable hour meter monitors hours of operation providing an indication of when the lamps may need replacing.

Alarm Buzzer

The audio alarm will indicate a system failure when the ultraviolet intensity drops below a set point (e.g. 16,000 µw-sec/cm^2). The alarm can also be equipped with a flashing light.

Solenoid Shut down

For smaller units with pipe diameters less than 2”, the system can be shut down with a solenoid valve if the dosage drops below a preset point (e.g. 16,000 µw-sec/cm^2).

For further information on related topics, please visit our website

Resource Management Branch

www.agf.gov.bc.ca/resmgmt

Linking to our

Publications and Conceptual Plans

FOR FURTHER INFORMATION CONTACT:
Ted Van der Gulik, Senior Engineer
Phone: (604) 556-3112
Email: Ted.vanderGulik@gems8.gov.bc.ca

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture, Food and Fisheries
1767 Angus Campbell Road
Abbotsford, B.C. CANADA V3G 2M3