Export of Ultra-Violet Water Disinfection Systems to Nepal

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INTRODUCTION:

In Nepal, like many other developing countries, water quality is an issue as it is easily contaminated with feces, chemicals, and runoffs, so it is a priority to governments to support projects that improve crucial aspects of life, like water quality (Gadgil, 1998). In Nepal, water contamination by arsenic, bacteria, protozoa, parasites, and viruses are main concerns as they are the most common (Gadgil, 1998). The product researched is an ultra-violet water disinfection system, made in Guelph, Ontario by Viqua (Viqua, 2016). This paper will outline the need for water disinfection in developing countries, such as Nepal and what is currently used, specifics about the product and how it will help the Nepalese, the benefit to Canada, and a final recommendation on if this product would be practical to export to Nepal.

OVERVIEW OF AGRICULTURE IN NEPAL:

Nepal is a small landlocked, mountainous country bordered by China and India (Government of Nepal , 2016). Nepal is split into three regions: mountain, valley and terai based upon their climate and altitude (Government of Nepal , 2016). Nepal is one of the poorest, least developed counties globally with agriculture supporting the economy (Rventures , n.d.), yet agriculture is minimally developed and there is much room for increased efficiency (Bhatta, Ishida , Taniguchi, & Sharma, 2008) as about a quarter of the population is living below the poverty line (Rventures , n.d.). The existing agriculture in Nepal is primarily subsistence agriculture, meaning that families only produce enough for themselves and produce little or none as a cash crop to sell (Maharjan & Joshi, 2012).

DRINKING WATER QUALITY IN NEPAL:

Drinking water quality in some developing countries can be compromised by bacteria, protozoa, parasites, viruses, chemicals, and minerals due to contamination by human and animal waste, minerals in the soil and rock as well as chemical leaching or runoff (Gadgil, 1998). Some of these bacteria, protozoa, parasites, and viruses cause diarrheal diseases, which after multiple infections can cause stunted growth in children. This can also lead to significant economic loss for adults due to missed work and results in a decrease in good nutrition available for children (Gadgil, 1998). To test for fecal contamination, indicator species are used to determine the origin. *Escherichia coli* is the most common indicator species for feces and in many countries feces are a main source of contamination due to a lack of proper disposal of human and animal waste (Gadgil, 1998).

Changes in climate have the potential to increase the incidence of severe weather events, which will put stress on water disinfection practices in Nepal (Gadgil, 1998). Drought causes an increase in concentration of bacteria, protozoa, parasites, and viruses in the water and flooding causes stress on water filtration systems as large amounts of sand and silt can be washed onto water filters clogging them (Gadgil, 1998). There is also an increase in salinity of ground water in some developing countries due to the fact that the volume of water being drawn from ground water sources exceeds the rate at which it can be replenished (Gadgil, 1998). All of these circumstances combined make an ideal environment for change but, in the efforts to increase water quality in developing countries, the goal is to decrease the incidence of bacteria, protozoa, parasites, and viruses in the water, not eliminate the contamination (Gadgil, 1998). This provides less risk for people drinking the water as pathogens have different minimum infectious doses (Gadgil, 1998). The minimum infectious dose varies depending upon the pathogen and indicates how much of a bacteria, protozoa, parasite, or virus needs to be ingested to make the illness take effect (Gadgil, 1998).

In Nepal specifically, about 90% of drinking water in the lowland Terai region is from shallow tube wells (as seen in Figure 1) that have been built in the last 20 years to provide improved access to water at a lower cost; about 60% of these wells are contaminated microbially as well as about 3% being contaminated with arsenic (Shrestha, Ngai, Dangol, Maharjan, & Murcott, 2007). This is due to poor drilling techniques, poor sanitation, and in the case of arsenic a surplus in arsenic found in the soils in that region (Shrestha, Ngai, Dangol, Maharjan, & Murcott, 2007). To combat this, the Nepalese government has promoted the installation of *Kanchan* ^{TM} Arsenic Filters, which are slow sand filters and are easily produced for a small expense by the Nepalese (Ngai, Shrestha, Dangol, Maharjan , & Murcott, 2007).

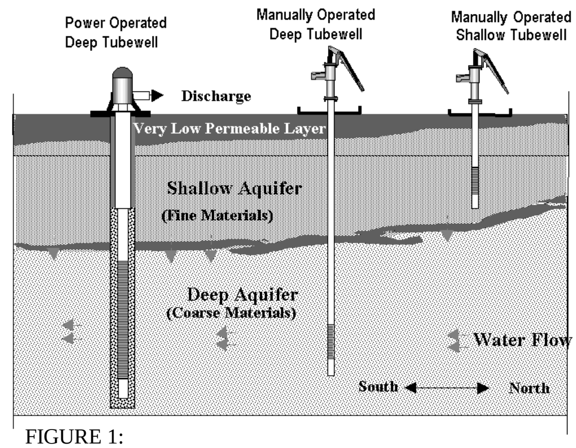

FIGURE 1:

[Well types]. (n.d.). Retrieved November 28, 2016, from http://users.physics.harvard.edu/~wilson/arsenic/conferences/Feroze_Ahmed/Sec_2.htm

PRODUCTS AND METHODS TO IMPROVE DRINKING WATER QUALITY:

CHLORINATION

Chlorination is the most common form of water disinfection globally and can effectively in kill bacteria, microorganisms, viruses, and protozoa as well as leaving a residual disinfecting effect on the water as it is not removed (Gadgil, 1998). This system becomes less useful as the concentration of contaminant increases as more chlorine is needed and in turn more wait time is needed for the water to be safe to drink; another drawback is that there is residual taste left in the disinfected water which is undesirable (Gadgil, 1998).

SLOW SAND FILTER

Slow sand filters (as seen in Figure 2) filter water to reduce the concentration of bacteria, microorganisms and viruses with a layer in the filter called the smutzdecke, which is a layer of bacteria, protozoa, amoebae, Crustacea and other small organisms which encourage microorganism predation (Gadgil, 1998). Slow sand filters work better than rapid sand filters as the water is drinkable once filtered and the filters are more simple to operate (Gadgil, 1998).

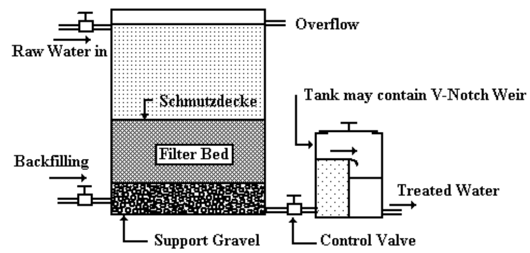

FIGURE 2:

Rapid Water Disinfection System [Digital image]. (1997). Retrieved November 28, 2016, from http://oasisdesign.net/water/treatment/slowsandfilter.htm

RAPID SAND FILTER

Rapid sand filters (Figure 3) are used primarily to remove the suspended solids from the raw water but can also reduce microorganism count; they do not disinfect water thoroughly enough to be used for drinking water and are therefore used primarily to prepare water for other forms of disinfection such as ultra-violet or chlorine (Gadgil, 1998).

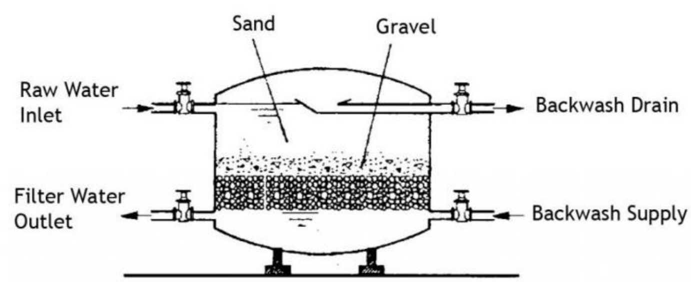

FIGURE 3:

Rapid Sand Filtration [Digital image]. (2012, February 21). Retrieved November 28, 2016, from Rapid Sand Filtration

SOLAR WATER DISINFECTION

In solar water disinfection, raw water is put into clear polyethylene terephthalate (PET) bottles and left in the sun for at least 6 hours to kill microbes in the water (Schmid , Kohler , Meierhofer , Luzi , & Wegelin , 2008). Solar water disinfection is used as a replacement to boiling water, which is a common practice in many developed countries when there is possible water contamination, because of the health risk associated with inhalation of smoke and the added cost of firewood (Schmid , Kohler , Meierhofer , Luzi , & Wegelin , 2008). Although there is some concern of chemical leaching of the bottles into the water in direct sunlight and therefore causing chemical contamination (Schmid , Kohler , Meierhofer , Luzi , & Wegelin , 2008).

ULTRA-VIOLET WATER DISINFECTION

An ultra-violet water disinfection system works by causing severe damage to the DNA of the microorganisms living in the water by preventing DNA replication, using light at a wavelength of 240 to 280nm (most effective at 260) (Gadgil, 1998). The disadvantage with UV water disinfection is that the water must not have too many suspended solids otherwise the light will not go through the water and will therefore not be disinfected as thoroughly. This technique of water disinfection is quick (takes only a few seconds), tasteless, and has no risk of overdose as in the case of chemical disinfectants (Gadgil, 1998).

ULTRA-VIOLET WATER DISINFECTION SYSTEM FROM VIQUA:

The product is an ultra-violet water disinfection system from Viqua (as seen in Figure 4). Viqua is a company that manufactures ultraviolet L.E.D. water disinfection systems in Guelph Ontario, and has been doing so for more than 35 years (Viqua, 2016). The company's goal is to kill microorganisms, protozoa, and bacteria that contaminate water to provide a clean, heathy source of drinking water. Viqua is "the world's largest supplier

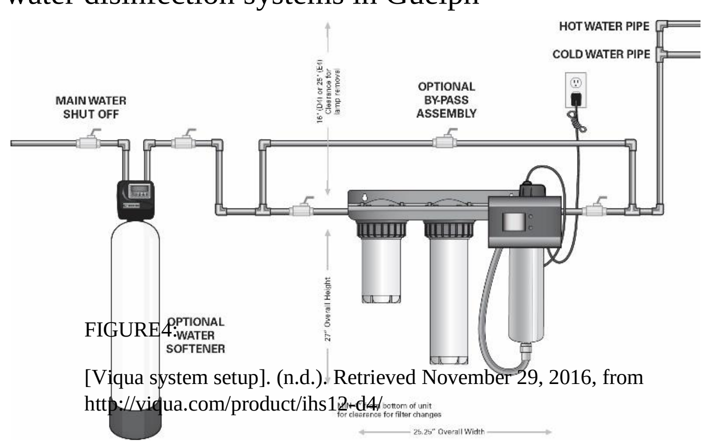

FIGURE 4:

[Viqua system setup]. (n.d.). Retrieved November 29, 2016, from http://viqua.com/product/ihs12-d4/

of residential and light commercial UV water disinfection systems." (Viqua, 2016). Using LED bulbs instead of the original mercury bulbs to disinfect water has made the systems much more efficient and environmentally friendly (Wurtele, Kolbe, & Jekel, 2011). This new and improved method of UV water disinfection is also cheaper, more compact, more convenient (due to it's minimal warmup time), and the bulbs have longer lifespans than the past models (Wurtele, Kolbe, & Jekel, 2011). The product also requires about as much electricity as a 40-watt light bulb, so it could easily be run by a solar panel if electricity is unavailable (Viqua, 2016).

TRANSPORTATION DISTRIBUTION AND COSTS:

There are different versions of the product available to fit different needs; there are systems available to kill bacteria, reduce turbidity, remove chlorine, and reduce smell as well as many different styles of systems, some that pre-disinfect and some that disinfect on demand (Viqua, 2016). For use in Nepal it would be difficult to gauge what the Nepalese people need and be difficult to choose a system seeing as though it may need to be modified to work on a hand pump and need to be modified to be run with solar panels as electricity may be difficult to access in some places (Viqua, 2016). An all-inclusive system from Viqua that reduces turbidity and cloudiness, chlorine and bacteria and is designated for higher volumes, called the IHS22-E4, the cost is about $1,495.99 (aquatell, 2016). A less complex system that would require prefiltration is the IHS12-D4, which is designated as a home unit and reduces chlorine and kills bacteria and costs about $1,125.99 (aquatell, 2016). To ship one unit from the manufacturing plant in Guelph to Kathmandu, Nepal through FedEx, it would cost about $1330.03 Canadian (FedEx, 2016). This gives the cost to the Nepalese at lowest $2 456.02- $2 826.02 which is about 201 018.84-231 302.37 Nepalese Rupees. there are also replacement parts to take into account, the most important being the bulb, which must be replaced once a year at a cost of $100-$140 and the quartz sleeve that covers the bulb must be cleaned once a year or as needed and replaced if broken at a cost of about $54 (Viqua, 2016).

The product could be sold to a variety of hardware wholesalers in Nepal to be distributed such as Akshar International Multipurpose Services Pvt. Ltd, Arun Iron Stores and Suppliers, Bageshwory Enterprises, or Karki and Companies.

BENEFITS TO NEPAL:

The Nepalese people and people from other developing countries continue to drink water contaminated by water-borne diseases because of drawbacks to improving the water sanitation process such as maintenance, high costs and lack of readily available parts and products (Shrestha, Ngai, Dangol, Maharjan, & Murcott, 2007). This causes the people to be infected with and suffer unnecessarily from water-borne pathogens such as *Escherichia coli, Giardia intestinalis,* and *Cryptosporidium parvum* (Gadgil, 1998), these pathogens can reduce work productivity and increase the number of days of missed school for children which in turn can exacerbate the poverty problem in developing countries such as Nepal (Shrestha, Ngai, Dangol, Maharjan, & Murcott, 2007). This will improve access to safe clean water could improve work productivity and attendance at school which in turn will improve the quality of the workforce and the ability for adults to feed and support their families. In adapting the UV L.E.D. water disinfection system from Viqua, the user would be able to more effectively kill microorganisms, protozoa, and bacteria such as *Escherichia coli, Cryptosporidium,* and *Giardia* (Hijnen, Beerendonk, & Medema, 2006), which can have serious health effects, such as severe diarrhea, hemorrhagic colitis (bloody diarrhea), kidney failure, and death in the case of *E. coli* (Pell, 1997). *Escherichia coli, Cryptosporidium,* and *Giardia* can all be transferred by the drinking of water contaminated by the feces of contaminated animals. *Cryptosporidium*, and

Giardia are especially difficult to control as there are few treatment options once infected (Pell, 1997).

BENEFITS TO AGRICULTURE

Women and children do most of the physical labour in countries such as Nepal so improving water quality would improve productivity and in turn the crops as the women and children would be sick less often and would grow better and be stronger to do the hard, physical labour in the fields (Gadgil, 1998). This would also give the Nepalese people more time, money and energy to better feed and support their families (Gadgil, 1998).

BENEFITS TO CANADA:

Seeing as though the manufacturer of Viqua is located right here in Guelph, an increase in demand would also increase the number of people employed by the manufacturer or the number of hours they have available to work. This in turn will help to better support the employees, giving them the ability to pay off debt, afford to buy more locally produced fresh food, and support other businesses in the community. (Central Intelligence Agency, n.d.)

EMPLOYMENT IN GUELPH:

The population of the city of Guelph is growing over time but the employment rate is decreasing, exporting a product manufactured in Guelph will help to draw or keep people in the city because of the jobs or increased ours created (statscan , 2016).

RECOMMENDATION:

This product may not be suitable for export to Nepal for a couple of reasons. One of which is that the Viqua system is very expensive as well as it being expensive to transport to

Nepal. Seeing as though many of the farms in Nepal are subsistence farms there is little cash crop and therefore little extra money to spend on an expensive water disinfection system no matter how beneficial to the health of the people. Another drawback is that this product is designed to be attached under the sink in a home in a developed nation so adapting the system to work on a hand pump may be difficult as there isn't a consistent flow of water and that the system requires a little electricity to run so that would have to be provided or solar panels must be purchased (Viqua, 2016). Also, the Viqua filters will not remove arsenic from the water which is also a huge problem in Nepal and surrounding countries so the Nepalese people are more likely to choose a water disinfection route that includes the removal of arsenic from the water.

One of the biggest challenges to safe drinking water in developing nations is keeping water clean after it is disinfected (Gadgil, 1998), so it might be more beneficial to the population of Nepal to provide clean tanks to store water or another product that would make storage of water less likely to be contaminated. Nepal already has some water disinfection processes in place as the government supported a project installing *Kanchan Arsenic Filters* ™ in the terai region of Nepal (Ngai, Shrestha, Dangol, Maharjan, & Murcott, 2007).

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FOR IMAGES:

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