Memorandum

To: Dr. Odem; Grading Instructor

From: Camille White, CENE 476 Student

CC: CRKL Engineering and Dr. Baxter; Technical Advisor

Date: December 1, 2016

Subject: Sustainable Water Treatment Literature Review

Objective

CRKL Engineering is creating a water treatment device to treat groundwater that has been contaminated with arsenic and nitrate. Conventional, sustainable and innovative methods must be researched to make a viable decision about the best available treatment option. The chosen method will be utilized to build a bench scale model throughout the Spring 2017 semester. The methods researched must address arsenic and nitrate levels of 1-2mg/L and 25-40mg/L, respectively. This document provides information regarding an sustainable treatment technique for both arsenic and nitrate.

Arsenic Removal

The treatment technique applied for arsenic must effectively remove this contaminant to a maximum of 0.01 mg/L, which is the drinking water standard set by the Environmental Protection Agency (EPA) [1]. Phytoremediation is the sustainable technology that was discovered through research of treatment techniques. This can be used interchangeably as an innovative or sustainable solution. This technology utilized aquatic plants to reduce high levels of arsenic from groundwater [1].

One study that was found demonstrates that dried roots of the water hyacinth plant will create rapid arsenic removal in water [2]. The hyacinth plant is found in many waterways around the world, making this a viable technology for any community. The sample preparation required for this study included gathering hyacinth plants, washing them with deionized (DI) water and leaving the plants out to dry [2]. Plants were then ground into a fine powder using lab equipment. Different milligrams of roots per milliliter of contaminated solution were observed to find optimum removal efficiency of arsenic. A mass-to-volume ratio of 30 mg roots per mL of solution was adopted for the remainder of testing after seeing almost 100% removal at this level [2]. This procedure also showed that optimum removal conditions were reached when water sources had a pH between 2.5 and 8.0. It was observed that hyacinth roots are negatively charged, which means at a low pH, the number of negatively charged groups available for arsenic will be decreased [2]. Analysis of the research proved that 93% of arsenite (As III) and 95% of arsenate (As V) were effectively removed from a 0.2mg/L arsenic contaminated source within 60 minutes [2]. In the end, it was discovered that 1000 liters of water could be treated using 30 kilograms of dried roots.

This technology could be used as a filtration steps in the bench scale model design. Not only will it effectively remove high levels of arsenic, but it can also be seen as sustainable due to the low operation cost and easily available media.

Nitrate Removal

The treatment technique implemented must reduce nitrate levels from 25-40 mg/L to the EPA drinking water standard of 10 mg/L [1]. A sustainable technology that was found through research is the reduction of nitrate using autotrophic bacteria (ARoNite). This technology requires no organic carbon addition, uses hydrogen as a low-cost electron donor, is non-toxic, and has a low waste yield [3]. One downfall of this technology is that the hydrogen used as the electron donor is highly flammable, which will require extensive lab safety.

Through research, a successful example of this treatment method was found in Rancho Cucamonga, CA where APT Water gained drinking water approval in 2013 after applying ARoNite [3]. The process used is a fixed-film biological treatment for the removal of oxidized contaminants [4]. Naturally occurring bacteria that use hydrogen has as an electron donor take carbon needed for cell synthesis from naturally occurring bicarbonate in a water source [4]. A membrane media is used to capture a naturally occurring bacteria culture. The autotrophic bacteria incorporate inorganic carbon from trace nutrients in the inflowing stream to create cell mass. The nitrate levels are then reduced using hydrogen gas as an electron donor. Nitrogen gas and clean water are the effluent that is produced. Hydrogen is delivered to the media and the biomass demands hydrogen, which diffuses across the membrane and is consumed during respiration [4]. Figure 1 below shows a diagram of the ARoNite media and treatment process.

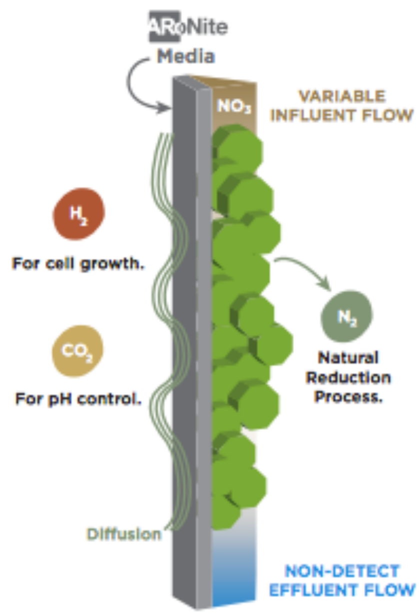

Figure 1: ARoNite Media Treatment [4]

This method is viable for use because the ARoNite systems do not present owners with a permitting cost and complexity problem that other treatments involve [4]. ARoNite process is proven to reduce influent water with up to 150 mg/L of nitrate, produces less biomass and waste than other treatments, eliminates the need for resin regeneration and is environmentally friendly due to onsite hydrogen production availability [4]. A hollow fiber media that will serve as a biological growth platform and gas delivery system, hydrogen, and carbon dioxide will be needed to make this solution feasible [5]. If this treatment is chosen, a phone interview with APT Water may be necessary to receive technology details or additional information regarding this treatment.

Summary

A sustainable treatment method for both arsenic and nitrate were discovered through research. Phytoremediation using hyacinth plants will allow a low cost, readily available source for arsenic removal in groundwater sources. The study found returned results of effective removal, meaning the effluent levels were below the EPA drinking water standards. For this treatment technique to be viable, there must be regulated pH levels in the water and a source to obtain hyacinth plants. To use ARoNite media nitrate removal techniques, APT Water, an engineering company, may need to be consulted to determine necessary treatment details. This technology requires low maintenance and low-cost, which require a hydrogen source, carbon dioxide source, and hollow fiber media. Both technologies discovered are feasible options to implement in a bench scale model design.

References

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