DEVELOPMENT OF AN ARSENIC MITIGATION STRATEGY FOR BANGLADESH

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Executive Summary

An activated alumina-based arsenic removal device has been developed and optimized for arsenic removal from well water in rural Bangladesh. The cost of implementing this plan is $4.79 per person, for each of the 80 million people affected. The cost over the ten year lifespan of the project is $383 million. The activated alumina device is designed to connect directly to the existing pumps used to draw water out of the wells, and to provide clean water at a spigot on the side of the device.

Bangladesh has a population of 140 million people. Since 1993, arsenic contamination has been discovered in the majority of Bangladesh's groundwater wells. The World Health Organization (WHO) standard for arsenic in drinking water is 10 ppb or less. Thirty million people in Bangladesh are currently drinking water with greater than 50 ppb arsenic, and fifty million people are drinking water with levels between 10 and 50 ppb. The figure below illustrates the widespread nature of the problem, by showing the percentage of people in each region of the country drinking toxic levels of arsenic.

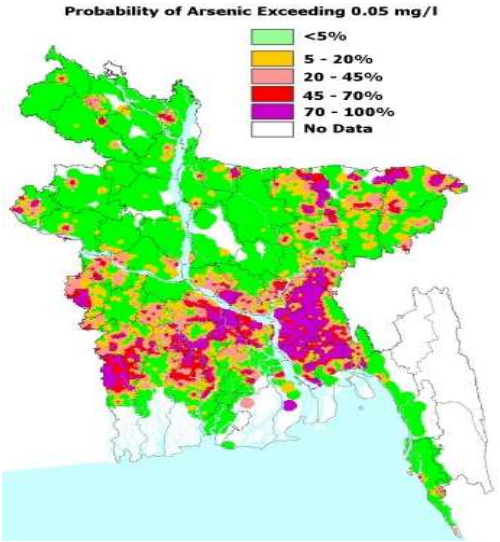

Figure 1: Extent of Arsenic Contamination in Bangladesh

A plan for country-wide arsenic mitigation is proposed, which prioritizes unit placement based on the level of arsenic contamination. Before this plan is implemented on a national level, it is proposed to carry out a pilot project in Gazipur Union, in the Haim Char Sub-District of the Chandpur District. This small region of 5,500 people is at high risk for arsenic poisoning. Both user feedback and performance data would be used to refine the design of the unit before wide scale implementation.

A diagram of the arsenic removal device is shown below, and is followed by a table summarizing the key design aspects of the device.

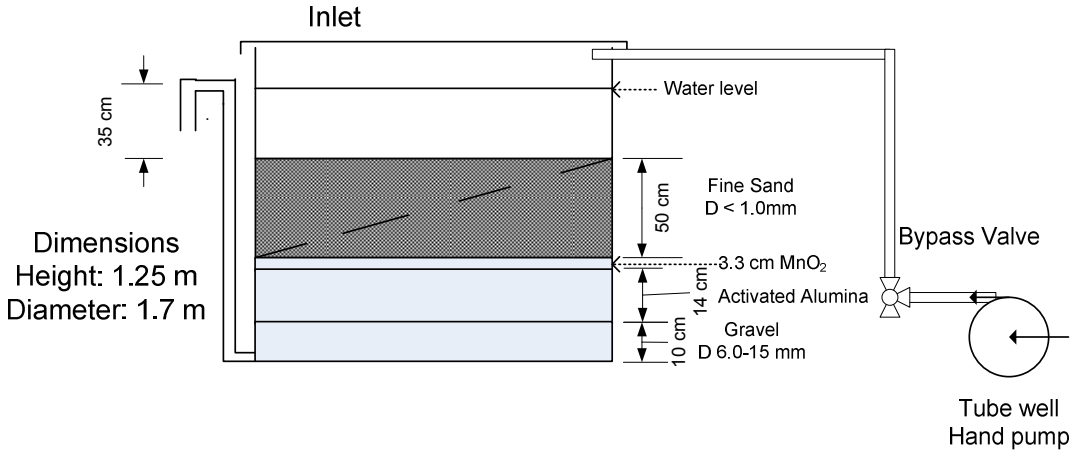

Figure 2: Diagram of Activated Alumina Arsenic Removal Device

Table 1: Properties of the Activated Alumina Arsenic Removal Device

Variable	Optimized Value
Shape	Round
Diameter (cm)	170
Sand size (mm)	0.35
Hydraulic Loading (L/hour)	400
Standing Water Height (cm)	35
Fine Sand Depth (cm)	50
Gravel Depth (cm)	10
MnO_2 Depth (cm)	3.3
Activated Alumina Depth (cm)	14
Total Unit Height (cm)	125
Total Unit Height (ft)	3.7
Mass of MnO_2 (kg)	114
Mass of Activated Alumina (kg)	254
Sand Filter Maintenance	Wet harrowing

Activated alumina and reverse osmosis based designs are studied in this report, and compared to two designs developed by other researchers. The activated alumina device minimizes overall cost per person and is easier to use, thus it was chosen to place at each arsenic-contaminated well head. The table below summarizes the key comparisons made.

Table 2: Comparison of Activated Alumina with Other Arsenic Removal Devices

	Activated Alumina	Reverse Osmosis	Iron Oxide Coated Sand	Arsenic BioSand Filter
Advantages	Simple, Economical	Simple Operation	One Step Process	User Friendly
Disadvantages	Large diameter- 5.6 ft	Rejected water; Requires pressure	Sand manufacturing is complicated	Unconventional; Inconsistent results
Cost Install Maintenance	 $1140 $29.33	 $290 $31	 N/A N/A	 $40 N/A
Cost/Person/Yr Install Maintenance	 $4.56 $0.12	 $29 $3.10	 N/A N/A	 $4.00 N/A
Arsenic Removal	Sufficient	Sufficient	Sufficient	Inconsistent results
Design	Slow sand filter plus MnO_2 and alumina	Slow sand filter followed by membrane	Iron Oxide Coated Sand used in slow sand filter	Slow sand filter plus rusted nails
Lifetime	20 years for AA & MnO_2 replacement	3 years membrane replacement	Replace/regenerate	N/A
Maintenance	Regenerate AA yearly	Membrane lasts 3 years	Must Replace Sand	Must Replace Nails
Manufacture	Very similar to slow sand	Slow sand plus RO unit	Complicated sand manufacturing	Addition of nail container
Credibility	Untested; technically sound	Trusted, design in use	OU Master Thesis Environmental Engineering	MIT MBA Report

The manufacturing and distributing of these devices will increase as time progresses, contingent on funding also increasing. At the beginning of the project, only 20 devices per month are manufactured, requiring only $25,000 per month. At the end of the project, over 6000 devices per month are manufactured, requiring

nearly $8 million per month. The figure below demonstrates how the required funding per month increases as the project grows in scale.

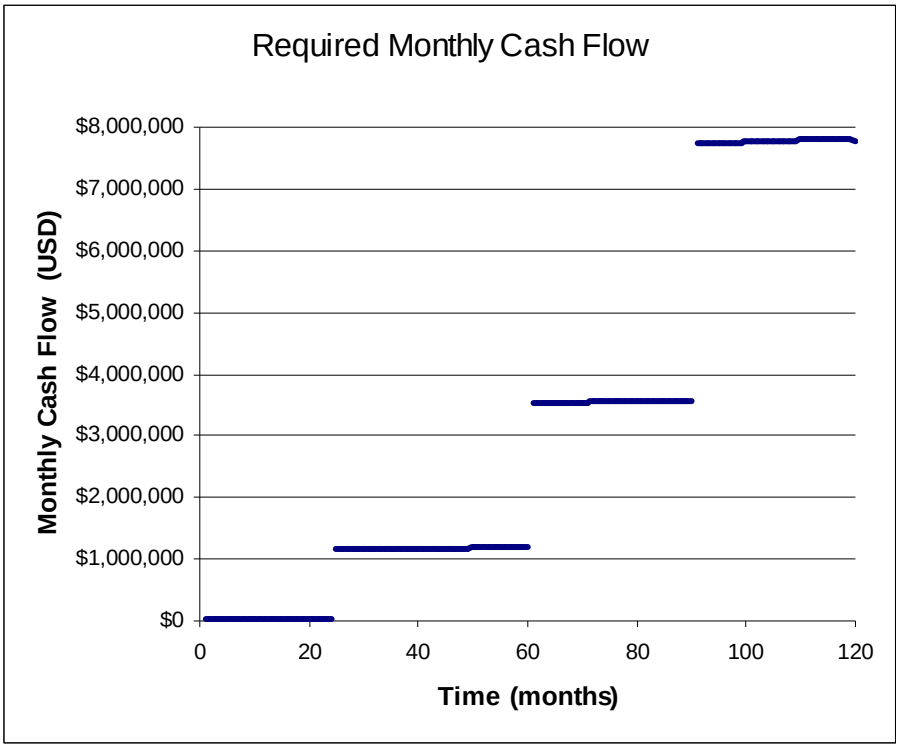

Figure 3: Required Monthly Cash Flow

Arsenic in groundwater is an immediate health risk to approximately 80 million people in Bangladesh. It is recommended that immediate action be taken to begin the mitigation process.